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Technoetic Arts

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Volume Six Number One

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Technoetic Arts: A Journal of Speculative Research
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Purpose of the Journal

The journal aims to provide a forum for the presentation of new ideas, projects and practices arising from the confluence of art, science, technology and consciousness research. It has a special interest in matters of mind and the extension of the senses through technologies of cognition and perception. It will document accounts of transdisciplinary research, collaboration and innovation in the design, theory and production of new systems and structures for life in the twenty-first century, while inviting a re-evaluation of older world-views, esoteric knowledge and arcane cultural practices. Artificial life, the promise of nanotechnology, the ecology of mixed reality environments, the reach of telematic media, and the effect generally of a post-biological culture on human values and identity, are issues central to the journal's focus. It welcomes speculative and anticipatory approaches to research, and the unorthodox expression of ideas whenever the topic justifies such innovation. It aims to communicate to an international non-specialist readership.

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VR and hallucination: a technoetic perspective

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Abstract

Virtual Reality (VR), especially in a technologically focused discourse, is defined by a class of hardware and software, among them head-mounted displays (HMD); navigation and pointing devices; and stereoscopic imaging. This presentation examines an experiential aspect of VR. Putting 'virtual' in front of 'reality' modifies the ontological status of a class of experience – that of 'reality'. Reality has also been modified (by artists, new media theorists, technologists and philosophers) as augmented, mixed, simulated, artificial, layered and enhanced. Modifications of reality are closely tied to modifications of perception. Media theorist Roy Ascott creates a model of three VRs: verifiable reality, virtual reality and vegetal (entheogenically induced) reality. The ways in which we shift our perceptual assumptions, create and verify illusions and enter 'the willing suspension of disbelief' that allows us entry into imaginal worlds is central to the experience of VR worlds, whether those worlds are explicitly representational (robotic manipulations) or explicitly imaginal (artistic creations). The early rhetoric surrounding VR was interwoven with psychedelics, a perception amplified by Timothy Leary's presence on the historic SIGGRAPH panel, and the Wall Street Journal*'s tag of VR as electronic LSD. This article discusses the connections – philosophical, social-historical and psychological-perceptual between these two domains.*

Keywords

VR
hallucination
psychedelics
reality
extended perception
immersion
neural plasticity
cyborg

1. Introduction

Cultural theorist Chris Chesser (1994) states:

> 'VR originated within marginal subcultures: from science fiction, cyberpunk, and computer hacker culture, and from institutions including NASA, computer companies, and the military. Perceiving much wider applications than flight simulation and remote control, researchers coined the term 'virtual reality', and promoted it as a paradigm shift for computers, and even for the whole society. The shift, though, was not into empty terrain: it was into such existing fields as entertainment, art, architecture, design and medicine. […] Moving from marginal cultural tributaries into the cultural mainstream, though, VR itself had to change; it needed to remove its uncomfortable associations with social criticism, drugs and insanity.'

New media artist, theorist and educator Roy Ascott has been concerned with the connections between technology and consciousness since his early papers on cybernetics and computers. Ascott (2003) speaks of 'a technoetic aesthetic, so named because I believe we need to recognize that technology plus mind not only enables us to explore consciousness more thoroughly but may lead to distinctly new forms of art, new qualities of mind, new forms of cognition and perception.' It is at this interface of mind and technology that the variety of VR experiences, changing and expanding with new technologies (hardware, software, bandwidth), and the varieties of psychedelic experience, connected to the ancient technology of psychopharmacology, can be compared. This inquiry is clearly transdisciplinary. My approach has more to do with discourse analysis than science or engineering, identifying and elaborating a few themes that have parallels in both VR and psychedelic studies. On the hardware side of the equation, I am using VR in a broad sense, as the whole class of technologies, not limited to head-mounted displays (HMD), by which we can interact with 'a computer-simulated environment, be it real or imagined' (Wikipedia, 2007). From the perspective of mind or mind states, a degree of immersion in an alternative reality (or world) is also seen as a defining characteristic of both the VR and the psychedelic experience.

This intertwined social history of the technological move to virtualize reality, and the varied uses of psychedelics by technologists is difficult to write for reasons R.U. Sirius (2007) states, summing up John Markoff's *What the dormouse said: how the 60's counterculture shaped the personal computer,* and Fred Turner's *From counterculture to cyberculture: Stewart Brand, the Whole Earth Network, and the rise of digital utopianism*:

> 'The connection between the creators of the driving engine of the contemporary global economy, and the countercultural attitudes that were popular among young people during the 1960s and 70s was sort of a given within the cultural milieu we ('High Frontiers/Mondo 2000') found ourselves immersed in as the 1980s spilled into the 90s. . . .
>
> Everybody was 'experienced' [. . .] But these upcoming designers of the future were not prone towards lots of public hand waving about their 'sex, drugs and question authority' roots. After all, most of them were seeking venture capital and they were selling their toys and tools to ordinary Reagan-Bush era consumers. There was little or no percentage in trying to tell the public, 'Oh, by the way. All this stuff? This is how the counterculture now plans to change the world.'

2. Technological highs

'High' is a major trope by which we refer to psychedelic states of a wide range of intensity from slight perceptual variations to full-blown replacement universes, far from ordinary reality. 'High' is also a ubiquitous trope of the electronic world, with its literal meanings attached to the parameters of signals (high frequency) shading into the intimations of increased pleasures of enhanced perception (high fidelity).

First, the psychedelic states. Human beings have been getting high from prehistory, according to one interpretation of cave paintings from 35,000 to 40,000 years ago as shamanic trance states in which human–animal transformations are depicted (Hancock, 2005). The anthropology of worldwide shamanism connects these pre-religious practices with psychedelic use from *ayahuasca* brews in South and Central America; mushroom use in the ancient Mayan and Toltec civilizations; and the *amanita muscaria* teas of Siberian shamanism (Wasson, 1986). Samorini's (2002) research with animals and psychedelics finds that 'Drugging oneself is an activity that reaches across the entire process of human evolution, from insects to mammals to women and men.' Psychedelics are implicated in the origin of religions, from the soma of the Vedas, to the *kykeon* of the Eleusinian Mysteries (Wasson, 2008). Psychopharmacologist Ronald K. Siegel (1989, 1993) argues that the drive to intoxicate ourselves is a natural part of our biology, the 'fourth drive' after food, sleep and sex.

Cannabis is famous for sensory reorganization and enhancement. Tart's (1971) exhaustive study identifies increased sharpness of edges; increased perceptual organization or 'meaningfulness'; new and more subtle shades of colour; increased perception of dimension of depth; increased perception of detail; and a sensual quality to vision, as if one were touching the things in sight. Music gains great clarity, resonance and meaning. These effects can be noted across the sensory palette, and could be described as greater fidelity, higher resolution. Mescaline, magic mushrooms, and 2-CB have been noted for their exquisite colour experiences: an extended range of colours, more subtlety, vividness, depth and texture (Shulgin, 2000). For a computer graphics practitioner, videographer, software designer and hardware junkie, this translates easily to the language of higher resolution, more pixels and 16 million colour palettes. Tart (1971) points out:

> 'It is common to assume that we passively 'see' what is out there, that the qualities of the visual world are inherent in the physical properties of objects and space. Modern psychological investigations have made it clear that seeing is a very active and complex process in which we construct the visual world from the flux of visual sensations reaching us. That is, patterns, forms, objects, recognizable people, etc. exist in our minds as a construction from visual data. We are so used to doing this automatically that it seems as if the visual world were given. This active nature of visual perception is true of all sensory modalities.'

In short, cannabis resets the resolution of our perceptions to a higher state, and the resultant aesthetic pleasures are part of the 'high'.

In my lifetime, I have been a consumer in the steady march from monophonic to stereophonic sound, and recall the ubiquitous term 'high fidelity' attached to every media system. My first VR gadget was a fully immersive Aiwa portable cassette player in the mid-1970s. The headphones welded to my ears delivered a heady stream of stereophonic Mozart operas. My senses, my emotions and, especially, the majority of my attention were immersed in the Queen of the Night's aria and Don Giovanni's demise while the rest of my senses dimly registered a humid dull Florida summer. Fast forward to high-definition TV, digital cameras with higher megapixels every few months, HD camcorders, huge screens, home theatres, iMax, fulldome theatres and surround sound. GPS systems pinpoint us to a higher and higher degree of resolution. Why do we want these things? The better to bomb you with? My roommate, studying to be a physician's assistant, howls in delight at the increase in graphics quality of his latest X-box first-person shooter, played on a standard-sized TV screen, while laughing with his girlfriend on the hands-free telephone device looped around one ear. There is some seriously immersive pleasure being generated here. Technology is driven at least in part by desire for highs – not only the desire for the orgasmic sublimities of Mozart (or Pink Floyd), but including the adrenalin highs associated with danger, self-defence and the violent fragmentation of other humans and destruction of property we find in computer games. On another spectrum, we experience the highs of connecting with friends and lovers on the cell phone – one after another – or Twittering (Twitter, 2007) to one's social network, a sensed surround of live attention-generating and capturing points of sentience like a quantum superpositional state out of which anyone could manifest with the announcement of an individualized ringtone. Let us not forget sex, about which cases have been made as our most powerful desire-to-get-high. John Perry Barlow (1990) states:

> 'Then there is the . . . uhhhm . . . sexual thing. I have been through eight or ten Q & A sessions on Virtual Reality and I don't remember one where sex didn't come up. As though the best thing about all this will be the infinite abundance of shaded polygonal party dolls. As though we are devising here some fabulously expensive form of Accu-jac.'

It is 2007: welcome to the Sinulator (2007) (advertising slogan – Do More Than Just Watch!) recently ported to Second Life where everyone is a party doll and fat flabby wrinkled avatars are in short supply. Sex sells – because it is a high. Technology discovers and delivers more and higher highs. And there is arguably a direct relationship between degree of immersion and degree of high delivered. And highs are nuanced – how can we describe 'the cool factor' that sent the addictive iPhone (aka Crackberry) flying out of Apple's warehouses last summer? What is more pleasurable and desirable about more pixels, finer colours, higher resolution (and a touch interface that has to be, well, caressed, to find a phone number) on bigger *and smaller* screens? I do not think it is a matter of mere verisimilitude to 'reality'. I do not think it is rational at all, though there are no doubt correlates we can objectively describe in the neurochemistry of pleasure that has been left a black box in this discussion.

This snapshot circa December 2007, of current technological delivery devices for highs will be staledated before it is printed – and that is part of my point. The strength of the desire for these highs is one of the factors driving change at an accelerated pace. We are following our bliss into technologically mediated hyper-realities.

Three features of these technologies are associated with 'highs': hyper-connectivity, hyper-conductivity, and processor speed. Hyper-connectivity can be seen in the myceliation of the nodes and links of high-density interconnected networks such as the World Wide Web. Within the world of the Web, the phenomenal spread of social networking takes the original migration of individuals, institutions, governments and corporations to create a 'web presence' to a new format of both presence and interconnection. Now it is not only a matter of 'Are you there?' but 'Who (and how many) are you connected to?' And the multimediation of presence – YouTube videos, Flickr photos, Mediafire music – are standard enhancements. Hyper-conductivity supports this drive to connect: higher bandwidth and mps/sec enable the faster up and download of higher resolution (larger file size) media. More bits and bit-torrents, music, entire movies, are moving faster and faster amongst us. Processor speed supports hyper-connectivity and hyper-conductivity. The replacement of silicon chips (still improving under Moore's Law) by quantum computers (or the next new architecture capable of speeds in orders of magnitude greater) will change the potential for connectivity and conductivity to a degree we can hardly imagine.

Psychedelic technologies produce the experience of hyper-connectivity with regularity. Rhetorician Rich Doyle's forthcoming book *Ecodelic* (2008) examines the fundamental experience of interconnectedness – with ourselves, our fellow humans and other species, feeling integrated with the biosphere, as a hallmark of psychedelic experience and a founding awareness of the ecological movement. Interconnectedness of thoughts and visions between persons is commonly reported in the literature of *ayahuasca* experience. As science fiction author Phillip K. Dick (1991) observed, 'We have to get over the idea that hallucination is a private matter.'

3. Immersion

Richard Lanham (1991) suggests that if we 'define rhetoric using a strictly contemporary terminology, we might call it the "science of human attention-structures". From this perspective, rhetoric has a "scientific" subject matter which includes large parts of, for example, sociology, social anthropology, and behavioral biology.' Neuroscientist Karl Pribram (in Davidson,1982) places attention at the centre of consciousness, reminding us, following Ryle, that 'There is no mind without minding'. I would argue that immersion – a key descriptor of VR – is primarily a quality of consciousness that has to do, like every rhetorical device, with the capture and control of attention, a necessary condition for any interpersonal persuasion, education or entertainment to occur. Absorption, defined as 'a state in which the whole attention is occupied' that Roy Ascott tells us is succeeding immersion, is a deeper degree of the same phenomenon, shading into trance and hypnotic states. 'Mind control' may be a more ubiquitous phenomenon than secret government projects (some of which involved LSD) as any parent standing between a TV and a child to recapture attention can attest. In literature and narratology, a phenomenon known as the 'deictic shift' signals the immersion of the reader in the story world at the point where he/she assumes a viewpoint (the deictic centre) within the story, from which their generation of the world *as world* is generated, and from which the unfolding of the story, guided by the storyteller, takes place. Author and critic Doris Grumbach speaks of the 'narrative dream' – the goal of the author being to immerse the reader in such, not waking her/him by jarring inconsistencies in the world that 'break' the narrative dream. The actual dream worlds of REM sleep that we visit nightly provide our most intimate experience of full immersion in worlds apart from waking reality. To know one is dreaming while it is going on (lucid dreaming) is a psychological skill that takes some training, so completely does the dream world capture us and carry us along in its narratives, replete with, in some cases, full sensory and emotional experience of imaginary activities, such as the classic dreams of flying, falling or transformation into different animal, human or spirit forms. The film trilogy *The Matrix* is a prolonged exploration of the theme of VR – a fully realized world-simulation – and dreaming. These themes are explored by several philosophers including philosopher of mind, David Chalmers, who presents the Matrix as a rendition of the philosophical thought experiment of the 'brain in a vat'. He defines a matrix as 'an artificially designed computer simulation of a world' (Grau, 2005). Can we define dreaming as an organically designed simulation of a world that persuades us as thoroughly as the waking world, as to its reality? Inquiry into the ontological status of an experience is a feature of both the VR and the psychedelic discourses, and the reality of dreams is invoked in both cases.

4. Reality, perception and hallucination

John Perry Barlow (1993) states:

> 'I think the effort to create convincing artificial realities will teach us the same humbling lesson about reality which artificial intelligence has taught us about intelligence [. . .] namely, that we don't know a damned thing about it. I've never been of the cut-and-dried school on your Reality Question. I have a feeling VR will further expose the conceit that 'reality' is a fact. It will provide another reminder of the seamless continuity between the world outside and the world within delivering another major hit to the old fraud of objectivity. '"Real"', as Kevin Kelly put it, 'is going to be one of the most relative words we'll have.'

Both VR and psychedelics raise ontological and epistemological issues; their practitioners can be framed as ontological engineers (not the database kind), hacking reality and constructing worlds. *What is real, what is reality,* jumps to the foreground as a practical issue, as well as a matter of nomenclature, with the question *how do we know that what we experience as real, really is real* hovering over the discourse. Psychedelics, with their ability to immerse the voyager in a distinctly different state, routinely raise these questions. Every decision by a game designer about the physics of a game world – including the decision to mimic real-life (RL) physics at all points, reveals virtual reality as a production of editable code, a set of rules about how a world works which the programmer controls, not an unchanging, eternal, universal and singular condition. Solidity, opacity, gravity are all decisions. Second Life is already a hybrid reality, allowing teleportation, bodily flight.

I am with Barlow in that I have no ambition to determine what reality *is*. To question the ontological status of a VR or psychedelic session is a common aspect of both experiences. What begins as an effort to determine 'What is real?' becomes an exercise in keeping the question open and an exploration of the notion of multiple mind states with concomitant multiple realities.

The Free Dictionary (2007) defines hallucination as '1a. Perception of visual, auditory, tactile, olfactory, or gustatory experiences without an external stimulus and with a compelling sense of their reality, usually resulting from a mental disorder or as a response to a drug. 1b. The objects or events so perceived. 2. A false or mistaken idea; a delusion.' *The Medical Encyclopedia* (2007) offers, 'Hallucinations are false or distorted sensory experiences that appear to be real perceptions. These sensory impressions are generated by the mind rather than by any external stimuli, and may be seen, heard, felt, and even smelled or tasted.' To call an experience a hallucination is an ontological assertion disguised as a psychological term. Every perceptual event with the label 'hallucination' presents a statement about the nature of reality, and a value position about the perceiver's status vis-à-vis consensus, socially approved standards of reality or its kissing cousin, truth. The association of 'hallucination' with pathological or otherwise negatively valued states was framed in the medical model of mind states and limits its usefulness as a term in the discussion of either VR or psychedelic states.

Roland Fischer (1971), professor of experimental psychiatry and pharmacology in the 1970s, early psychedelic researcher, and editor of the *Journal of Altered States of Consciousness*, proposed a cartography of states of consciousness that 'depicts increasing levels of ergotropic, central or hyperarousal on the perception-hallucination continuum, while the right side depicts an increase in levels of trophotropic or hypoarousal on a perception-meditation continuum (including zazen and various forms of yoga)'. Fischer defines hallucination as follows: 'The hallucinatory or waking-dream states along the perception-hallucination continuum can best be described as experiences of intense sensations that cannot be verified through voluntary motor activity. Note that such a definition does not differentiate between dreams and hallucinations. . .' The standard for reality (which is implied as opposite to hallucination) is defined in terms of baseline perception that can be verified by the senses, particularly the sense of touch. However, 'sensation' is used as a term for experiences all along the continuum. Placing the variety of experiences along a single continuum (later diagrams revising the model bring the hemisphere into a full circle) with both quantitative measures Electroencephalography (EEG) and subjectively reported experience (ecstasy, Samadhi) condenses a wide variety of experience into a linear scale.

Tom Roberts's (2006) multistate paradigm introduces a far more complex model of the variety of conscious or (his preferred term) 'mindbody' states. Roberts builds a set of parameters or subsystems of conscious (mindbody) states, using ten from Tart's 1976 classic *Altered States of Consciousness* – exteroception, interoception, input-processing, memory, cognition, emotions, motor output, identity, time sense, interaction – and adding two of his own, intuition and moral sense. He refers to other taxonomies of conscious states, especially Shanon's parameters from his study of *ayahuasca* mindbody states. Roberts points out the vast combinatorial possibilities in these 'compositions'. He also identifies two further components in addition to mindbody states of the multistate paradigm. *Mindbody psychotechnologies* designate methods for producing varying mindbody states: yoga, biofeedback, meditation, psychoactive drugs, spiritual practices including prayer, martial arts and others. *Residency* is 'the idea that all human behavior and experience occur in mindbody states. That is, a mindbody state provides a psychophysiological context (program) from which all behavior and experience grow.' Roberts deals with reality with the assumption that there is a 'real life' at baseline whose physical presence and experience we share, or assume we share, in daily life, and a 'land of make-believe' that encompasses narrative or fictional reality, dreams and psychedelic states, when we leave 'real life' and enter a 'mythopoetic reality', which he associates with psychological or spiritual realities of varying depth and impact. He avoids the term 'hallucination', describing these varied experiences in terms of multiple and shifting realities.

Normal, baseline perception presents its own complex relations to illusion, as the psychology of perception reveals. Alan Watts (2004) states:

> 'Most of us are brought up to feel that what we see out in front of us is something that lies beyond our eyes – out here. That the colors and the shapes that you see in this room are out there. In fact, that is not so. In fact, all that you see is a state of affairs inside your head. All these colors, all these lights, are conditions of the optical nervous system. There are, outside the eyes, quanta, electronic phenomena, vibrations, but these are not light, they are not colors until they are translated into states of the human nervous system. So if you want to know how the inside of your head feels, open your eyes and look. That is how the inside of your head feels. So we are normally unaware of that – projected out.'

The fact that we believe that we are seeing something 'out there', that we experience 'looking' as an act projecting *out* from the eyes into the environment, rather than a passive reception of vibratory signals, is a belief in an illusion – our own projection of an internal state onto the environment – upon which we craft our ongoing experience of reality. VR-engineered experiences and psychoactive materials each can change the conditions of these perceptual systems, and hence open new experiences of reality. If one changes the settings of a camera – aperture, shutter speed, film type and especially sensor type, from infrared to ultraviolet – one sees variations on a perceptual landscape. The human perceptual systems are far more complex. Psychopharmacology studies the ways in which these settings can be manipulated by shifting the actions and inactions of various nervous-system components by changing the circuitry of the nervous system via action by neurotransmitters on receptor sites. These receptors can be activated, deactivated, opened or blocked, thereby opening and closing potential pathways for signals to pass, making and breaking connections, amplifying or dampening signals. Psychiatry utilizes these changes to modulate feeling states and modify behaviour.

Watts (1972) relies on neuroscientist Karl Pribram's research into the mystery of what consciousness studies calls 'the binding problem', identifying the epistemological conundrum relating knowing with perception:

> 'I sat in on an intimate seminar with Pribram in which he explained in most careful detail how the brain is no mere reflector of the external world, but how its structure almost creates the forms and patterns that we see, selecting them from an immeasurable spectrum of vibrations as the hands of a harpist pluck chords and melodies from a spectrum of strings. [. . .] For Karl Pribram is working on the most delicate epistemological puzzle: how the brain evokes a world which is simultaneously the world which it is in, and to wonder, therefore, whether the brain evokes the brain. Put it in metaphysical terms, psychological terms, physical terms, or neurological terms: it is always the same. How can we know what we know without knowing knowing?'

Tom Ray, a biologist known for his research in complexity and artificial life, is following a new research path: understanding the chemistry of consciousness. He is mapping the 'receptor space' of hundreds, and potentially thousands, of psychoactive substances using the National Institute of Mental Health's 'supercomputer' program, the Psychoactive Drug Screening Program 'to screen drugs against the entire human 'receptome' (all receptors in the human body; over 300 in the brain). He sees the receptome as a vast and complex combinatorial space marked by certain attractors, representing 'major emotional states and moods, and whatever other mental phenomena the chemical systems are mediating'. From the viewpoint of neurochemistry, a similar picture of a vast and complex dynamical system of chemical states producing and being produced by mental phenomena emerges.

John Lilly (1991) gave the following definition of hallucination in an interview with David Jay Brown and Rebecca McClen:

> 'DJB: How would you define what a hallucination is?
>
> JOHN: That's a word I never use because it's very disconcerting, part of the explanatory principle and hence not useful. Richard Feynman, the physicist, went into the tank here twelve times. He did three hours each time and when he finished he sent me one of his physics books in which he had inscribed, 'Thanks for the hallucinations'. So I called him up and I said, 'Look, Dick, you're not being a scientist. What you experience you must describe and not throw into the wastebasket called "hallucination". That's a psychiatric misnomer; none of that is unreal that you experienced.' For instance he talks about his nose when he was in the tank. His nose migrated down to his buttonhole, and finally he decided that he didn't need a buttonhole or a nose so he took off into outer space.
>
> DJB: And he called that a hallucination because he couldn't develop a model to explain it?
>
> JOHN: But you don't have to explain it, you see. You just describe it. Explanations are worthless in this area.'

I prefer to substitute the more value-neutral term 'extended perception' for 'hallucination' to name the shifts in perception and reality brought about by psychoactive substances. Alan Watts (1962) makes the case:

> 'There is no difference in principle between sharpening perception with an external instrument, such as a microscope, and sharpening it with an internal instrument, such as one of these [. . .] drugs. If they are an affront to the dignity of the mind, the microscope is an affront to the dignity of the eye and the telephone to the dignity of the ear. Strictly speaking, these drugs do not impart wisdom at all, any more than the microscope alone gives knowledge. They provide the raw materials of wisdom, and are useful to the extent that the individual can integrate what they reveal into the whole pattern of his behavior and the whole system of his knowledge.'

4.1 Cyborgs and plasticity

Many of our common images of VR technologies call to mind the cyborg, from the variety of HMDs to the virtualization and transformations of the body in online game and social environments such as Second Life.

Figure 1: Ontological engineer.

The psychedelic technologies call forth strangely cyborgian images as well. The Mayan civilization used the psilocybin mushroom sacramentally, as a substance that released the vision serpent. Some of the depictions of figures in trance are distinctly technological in look and feel.

Andy Clark (2003) reviews our intimate relations with tools and technology as primary means of extending mental capacities (perceptual, memory storage, calculation ability) and intelligence. This capacity, underwritten by our unique neural plasticity, is a defining characteristic of humanness. Clark states:

> 'It is our special character, as human beings, to be forever driven to create, co-opt, annex, and exploit nonbiological props and scaffoldings. We have been designed, by Mother Nature, to exploit deep neural plasticity in order to become one with our best and most reliable tools. Minds like ours were made for mergers.'

Clark examines our cyborg nature not just as a recent phenomena involving bioelectronic interpenetration of the meat body as the gold standard, but in the far more pervasive relationship we have with non-biological technologies, such as language, so intimately, though not physically in a hardware sense, coupled with the body-mind. Our encompassing symbiosis with language is at once taken completely for granted in its functions and uses, and stands mysterious as to its actual nature, since even the manner in which our words and sentences are formed from thought is something that takes place behind the scenes of ordinary consciousness. Applying the label 'unconscious' has no real explanatory power except to point to a realm of mental functioning that only becomes known when it is no longer itself (unconscious) because some aspect or chunk of content (a dream, an insight, a long-forgotten memory) comes into consciousness.

Both VR and a host of psycho-spiritual technologies, including psychoactive drugs, have been used technoetically to launch raids on these inarticulate realms, normally hidden from the focused beam of conscious attention.

Figure 2: Sarcophagus lid, tomb of Pacal Votan, surrounded and supported by the architecture of visionary experience.

Margaret Dolinsky's CAVE environments take us into these imaginal worlds with a shamanic sense of double consciousness; we are both fully immersed in the sights and sounds of other worlds, while fully aware of our bodily presence. Stan Grof's extensive research in LSD psychotherapy with hundreds of patients used the powerful psychoactive to penetrate deeply buried unconscious content, a method dramatically more effective than Freud's dream analysis, which he called 'the royal road to the unconscious'. Lilly's early tank work involved his own observations of his mind at work under conditions of sensory deprivation and psychoactive excitation, during which he pushed the Freudian psychoanalytic model to self-understanding to limits Freud may not have envisioned, even with the aid of cocaine. For Lilly, the tank plus LSD (and later, ketamine) provided enough momentum to overcome what Freud termed the resistance of the individual ego to encounters with unconscious materials. With both VR and psychedelics, our perception, in Lilly's case into mental or imaginal realms normally hidden from view, is extended by technology.

Clark's normalizing view of our intimate relations with technology, of which VR is one aspect, is countered by Ascott's (2003) more radical view of VR.

> '. . . our current fascination with the theatre of the virtual has obscured the true destiny of virtual reality (VR). Its importance lies in its role not as a stage for the re-enactment of renaissance perspectives, but as a cultural phase space, the test-bed for all those ideas, structures, and behaviors that are emerging from our new relationship to the processes of evolution and growth, the challenge of artificial life.'

4.2 Technology mergers

Integrating the technologies of virtual reality and vegetal reality brings the association that was hyped in the late 1980s when VR became a mainstream media fascination into practical applications. I consider John Lilly, psychonaut, dolphin researcher and founding member of the Search for Extraterrestrial Intelligence (S.E.T.I)., an early VR researcher as the inventor, in 1953, of the isolation (flotation, immersion, sensory deprivation) tank. The tank is a literally immersive environment, a one-person VR installation (limiting, as does any theatre or VR set-up, visual and sonic input as well as minimizing motor activity and sensation through floating the body) where the sensory projections are provided by one's internal brain/mind processes. Lilly went on to add the additional technology of psychoactive substances to this mindbody technology system. The combined technologies became the protocol for much of his research in non-ordinary mindbody states. Terence McKenna followed a similar protocol, sans tank, of minimizing sensory input when he recommended '5 grams dried psilocybin mushrooms consumed in silent darkness'. VR technologies routinely screen out and/or replace everyday sensory input with technologically mediated sound, sight and other sensory input as the means of engineering different realities.

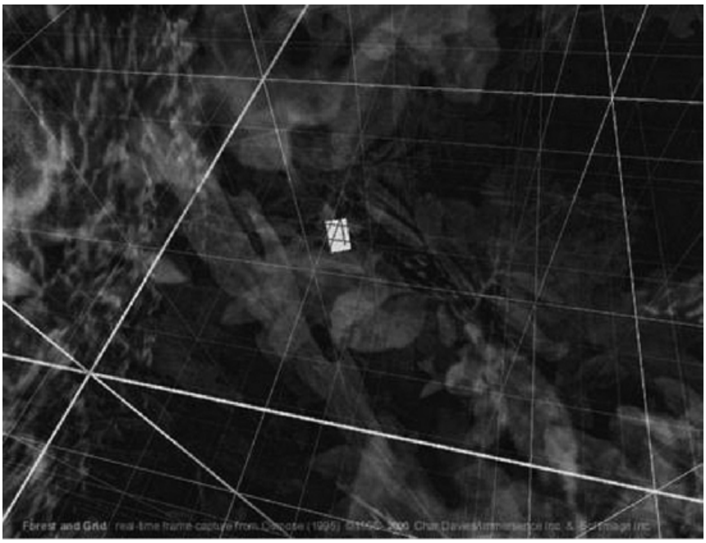

Figure 3: Char Davies's VR installation, Osmose.

Figure 4: Frame from LiveGlide video. LiveGlide is an interactive, 3D writing system for the dynamic visual language, Glide, designed and explored by Diana Slattery. It is best experienced in an immersive fulldome environment.

Reality, it seems, is multiple, and tightly coupled to perception. The conditions of perception can be varied within a broad range by a variety of technologies. Char Davies's full body and HMD installation *Osmose* provides an experience of physically floating through visual spaces that merge technological images with images from nature.

Lilly's flotation tank can send one into outer and inner spaces where the outer–inner differentiation is highly malleable. An immersive fulldome hemispheric projection of the universe with software such as Uniview (Rose Planetarium) can provide an interactive experience of scalar magnitudes and outer space exploration with no on- or in-body hardware. Any of these, and many other technologies, can be combined with psycho-spiritual technologies of altering mindbody states, including psychedelics, to create, again, a vast combinatorial space of possible experiences across Ascott's three VRs: verifiable reality, virtual reality and vegetal reality.

The hardware and software of virtual reality technologies combined with the instrumentation of neuroscience and the neurochemistry of consciousness alteration provide a toolset for the understanding of consciousness. My Ph.D. research into linguistic phenomena in the psychedelic sphere follows this path. Based on my own phenomenological explorations of psychedelic spaces, and informed by the descriptive reports of long-term psychedelic explorers, I have developed a linguistic model of a dynamic, multidimensional symbolic system, Glide, and developed a 3D software, LiveGlide, as a real-time, interactive writing system that is most effectively performed in immersive domed environments. While the output of the system can be 'performed' in an arts context, I primarily use it for the exploration of the interactions of language, perception and reality when reading and writing (itself a complex feedback loop) Glide in variously altered mindbody states. One of the intentions of my research is specifically aimed at perturbing and rewiring the language functions of the brain, to find, explore and describe new forms of cognition dissociated from natural language.

5. Conclusions

Reality is a personal matter. It is intimately dependent on perception. Perception is a complex internal process of multiple interacting systems (visual, auditory, linguistic) that takes wave information from the sensory systems and, through reference to sensory, emotional and linguistic memory in a dynamically mutable and complex chemical and neurotransmission space, constructs 'reality' on the fly in the experiencing individual. Not only *what* reality is being described but *whose* reality and under what perceptual conditions, cognitive preferences and epistemological biases needs to be considered. Intersubjective sharing through a variety of linguistic means (including body language, sounds, as well as more abstract symbolic systems such as natural language, music, gesture, dance and mathematics) creates the scaffolding for a shared or consensus reality. Both VR technology and psychedelic technologies extend perception and reorganize sensory ratios to create new experiences of reality, new epistemological platforms and the conditions for new knowledge acquisition in the fields to which they are applied.

How much and in what direction are we able to rewire our plastic neural circuitry? How drastically can we edit our genome, not only to prevent hereditary disease and defects but with a view to improvements, about which there is far greater moral hesitation? To what extent can we revise body-mind functions with implanted or replacement prosthetics, add-ons or plug-ins are matters spawning the newer disciplines of bioethics and neuroethics and raising issues of cognitive liberty. In what manner our technoetic experiments in VR and psychedelic technology contribute to the process of reflection on the nature and functioning of the human mind, and more directly to actual changes wrought (in the development of biofeedback applications in immersive environments, for instance) is subject for speculation. Technology is evolving at ever accelerating rates, and with it, massive cultural evolution. I relate to the drive toward 'higher' states to the drive that pushes us at breakneck speed into creating and using technologies with the potential of radically revising the state of human beingness. This drive is producing, among other things, the technologies of altering, extending and reorganizing perception and the new realities thereby opened to view.

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Designing mixed reality: perception, projects and practice

Peter Anders, Ph.D.

Abstract

Mixed reality is an increasingly prevalent technology that merges digital simulations with physical objects or environments. This article presents principles for the design of mixed reality compositions. The principles are illustrated by projects and experiments by the author involving architecture and robotics.

Keywords

architecture
cyberspace
virtual reality
mixed reality
cybrids
augmented reality

Introduction

Since completing my dissertation at the University of Plymouth, I have experimented with various technologies to test my thesis. The dissertation tried to answer a question arising from present technologies. If, as research suggests, simulation can compete with – or even supplant – their physical counterparts, what might its effect be on architecture? I found that such effects could apply to nearly any design field – namely, any that used representation (i.e. drawings, models, specifications) in generating a physical product (Anders 2005).

Such effects would not lead to complete virtualization. While an architecture of cyberspace may be possible, it can only be realized through the physical systems that sustain it. The virtual needs the material for its realization – even imaginary architecture requires the brain and body of the imaginer. Since our spatial imagination is a product of and tool for cognition I proposed that the virtual and physical are co-dependent and, possibly, inextricable.

This article proposes seven principles for designers who seek to integrate physical and virtual elements. These principles are illustrated by projects done over the past two years. These projects are not conclusive – each is still in development – however, even at their present stage they show the principles in action. Before proceeding, however, I should introduce some concepts used in this discussion.

Mixed reality

While we experience a form of mixed reality every day (virtual entertainments on physical screens, simulated voices on physical cellphones), *mixed reality* is a technology that reconciles and integrates virtual and physical worlds. The birth of mixed reality (MR) in 1962 coincided with that of virtual reality when Ivan Sutherland used transparent displays to place simulations into his lab space (Sutherland 1963). The term 'mixed reality', however, had to

Figure 1: A representation of Milgram and Kishino's virtuality continuum.

wait until 1994 when Paul Milgram and Fumio Kishino described technologies 'that involve the merging of real and virtual worlds somewhere along the virtuality continuum which connects completely real environments to completely virtual ones' (Milgram and Kishino 1994).

Along this continuum we find different blends of the physical and virtual (Figure 1). Toward the virtual end of the scale we find *augmented virtuality* in which physical elements are set into a virtual world. Its opposite, near the other of the scale, is *augmented reality* (AR) that places virtual objects into actual settings. These technologies are distinguished from simple visual collage in that the virtual and physical elements of a scene are linked. Namely, if you move your point of view actual and virtual objects move in parallax, as though they were in the same space. Effectively, the virtual and physical are conjoined in mixed reality.

The technology depends on our ability to make coherent space from sensory information. Seen as a product of consciousness, this space situates the artefacts of sensory cognition – colour, spatial relationships – and those of other processes like identification and memory. From this standpoint all objects: virtual, physical and imaginary, are potential occupants of psychosomatic space. And while we can distinguish their relative reality – virtual rocks cannot break physical windows – they cohabit quite comfortably in our day-to-day experience of the world.

Mixed reality, especially augmented reality, has become increasingly popular in computer science circles because of its unique challenges. Not limited to visual display, AR can also incorporate sound, touch and even smell depending on the application involved. Several professional organizations – such as ISMAR and special interest groups of IEEE – specialize in AR, and hold regular conferences on its use. AR projects regularly feature in arts and technology conferences such as SIGGraph, ISEA and Ars Electronica.

Cybrids

As mentioned, augmented reality places virtual objects into physical settings. This is what we usually see in typical AR projects, movie special effects or in advertisements where the featured cars do miraculous things. However, despite the placement of a virtual element in an actual scene, the two are distinct from one another. We rarely see the integration of virtual and physical objects within the same scene.

Somewhere between the extremes of Milgram and Kishino's mixed reality is a mid-point where integrated virtual/physical objects occupy a mixed reality space. These would incorporate the material presence of sensory objects with the capacities of virtual ones. Such hybrid objects, here called *cybrids*, would be the native occupants of mixed reality.

Examples of cybrids may be seen every day. For instance, a television set could be called a form of cybrid. It incorporates both the hardware for display, as well as the virtual space of the television image (at least when turned on). The physical apparatus generates the virtual image but the two are not integrated – action in the screen space does not affect the television set. A TV car crash, for instance, will not knock the television off the shelf. But knocking the TV off the shelf would certainly affect the cars on the screen! A proper cybrid would allow seamless interaction between its virtual and material parts.

Computers would be better examples than TVs since their operating systems manage interaction between the computer's hardware and software. The icons and graphics of the user interface constitute a kind of virtual space native to the computer. If we click the right virtual item on the screen, we can turn the computer off. If we then click the physical power button, we can restore the virtual space of the screen and its icons. The physical and virtual support one another.

Cybrid principles

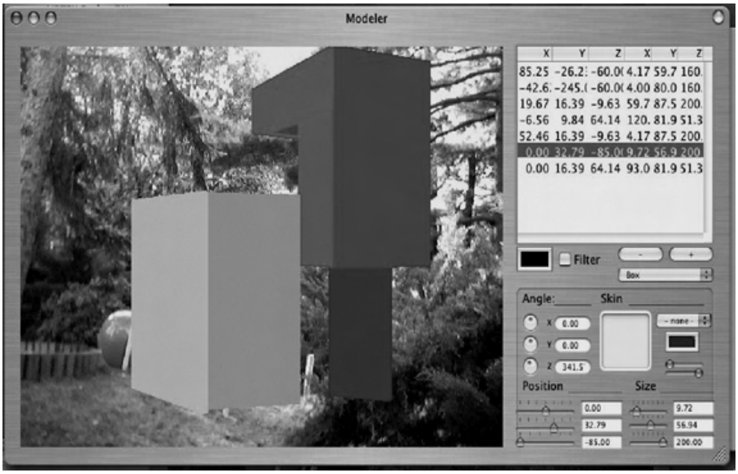
Cybrids and other mixed realities reflect the mixed reality of contemporary culture – a psychological and social blend of actuality and simulation. Accepting this we open onto a range of questions. How could we design for mixed reality? What would characterize cybrid designs, and how would they differ from other forms of design? In an effort to answer these questions, I have proposed seven principles for cybrid design (Anders 2005). I expand upon them here, illustrated with examples taken from my recent work.

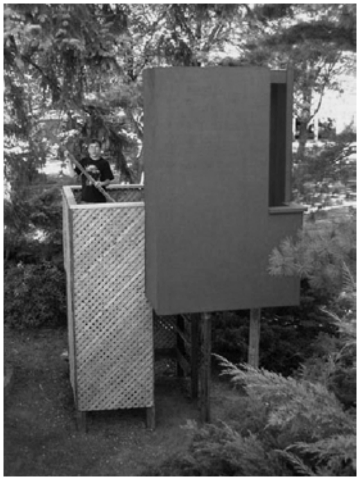
1. Comprehensive space: Cybrids exist in a comprehensive space that comprises the material, symbolic and cognitive attributes of spatial experience.

The idea of *comprehensive space* is particularly useful to designers of cybrids. It encourages development of projects free of bias towards either material or simulated solutions, offering instead the broad spectrum that lies between. As a mental frame for cybrid development it has useful entailments. For instance, cybrids evolve from a space recognized as a product of consciousness. This space pre-exists any of the project's manifestations, surviving until the last memory of the project is lost.

This suggests that the *life* of the project extends from the earliest inclinations of its creators to well beyond its construction. The cybrid is an evolving entity rather than a final product; it embodies the information of its design, production, use, transformation and eventual dissolution.

I have used this principle as the starting point for several projects, including an office space, a playhouse and a small robot. In all cases the virtual and material were considered subsets of a cognitive, comprehensive space. Of these projects the playhouse comes closest to conventional architecture, i.e. a design document preceded construction. In this case I used Werner Lonsing's mixed reality software, *AmbiViewer*, to outline the design on the site. The house was built from this mixed reality 'sketch' much as a normal project would be from working drawings. While I had anticipated using the house as a site for virtual exploration,





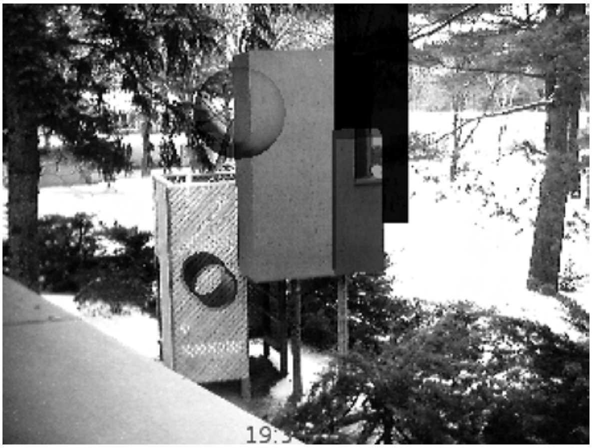


Figure 2 (upper left): The Ambiviewer interface showing an early model of playhouse. The mixed reality model is situated on-site using GPS and a visual fiduciary feature: the red object on the lower left.

Figure 3 (above): Playhouse as built from Ambiviewer model.

Figure 4 (left): Playhouse with virtual objects attached. The resulting cybrid is seen through the Ambiviewer interface.

the virtual components were designed and added later (Anders 2005) (Figures 2, 3, 4).

The virtual space was always part of the Caltech office space. Large, specially located mirrors reflect the offices beyond the confines of the building. This mirrored space is more than an optical illusion since the reflections are to be realized in cyberspace as a virtual annex that supports and *houses* the remote sales force and outlying services. This extension would be eventually viewed in online worlds such as Second Life (Figure 5).

A final example is a small robot I built recently to demonstrate the coupling of virtual and physical components. In this case the virtual and physical were considered simultaneously as parts of a composition. We will come back to the robot shortly.

2. Composition: Cybrids are mixed reality compositions that consist of material and simulated elements.

This principle concerns the integration of physical and virtual entities within a coherent design. A cybrid's composition may be observed in a variety of modes, through direct observation as well as by mediating

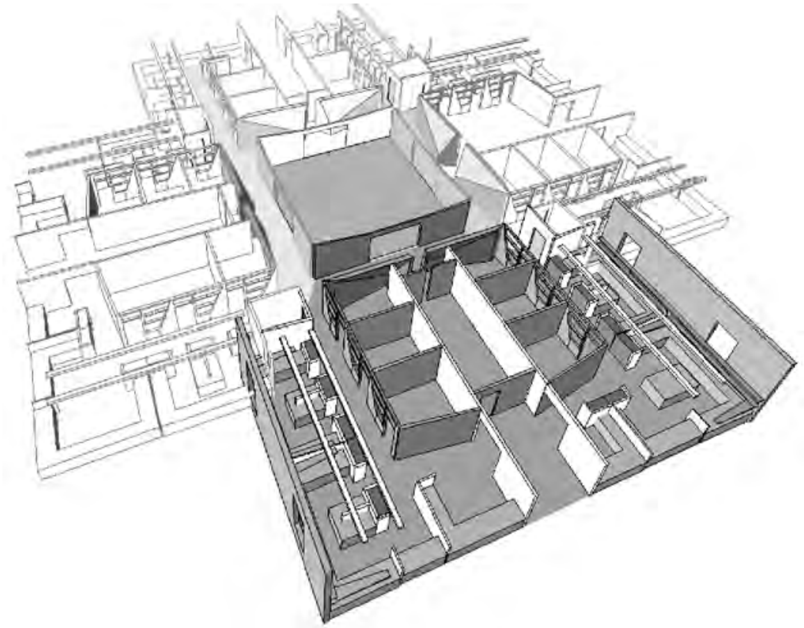


Figure 5: The diagram above shows the cybrid layout of the Caltech offices. Only the lower right quadrant of the plan is physical. The remainder (shown faded) is virtual, being reflected both in the scheme's large mirrors and as a navigable space in a 3D world. The online portion is in development as of this writing. The red square in the centre is a virtual conference room that will resemble the actual conference room in another part of the building.

technology. The design of the cybrid would determine the nature of constituent elements, as well as the type and number of techniques that would support it.

The office space and the robot were both designed with the virtual and physical components in mind. The playhouse was intended to be a test bed for mixed reality experiments. As such the cyberspace became an empty vessel to receive virtual elements. In this sense, the playhouse resembles aspects of my dissertation's proposal for the Planetary Collegium. There, too, the adjoining cyberspaces were to house virtual objects created after the project had been realized (Figure 6).

3. Corroboration: Cybrids offer a range of empirical modes that corroborate one another.

We interact with our world through several senses at once. For example, when I am chatting with a friend, the face of the friend appears to my eyes where my ears suggest it to be. The effect is crucial to my sense of being present in a space. This corroboration is a key element in cybrids as it leads to a unified effect for the observer. Corroboration can be achieved in part through composition, i.e. the physical configuration sculpturally suggests the virtual element, or by the orchestration of modes by which the cybrid is perceived. We can observe these modes directly through the senses or through their

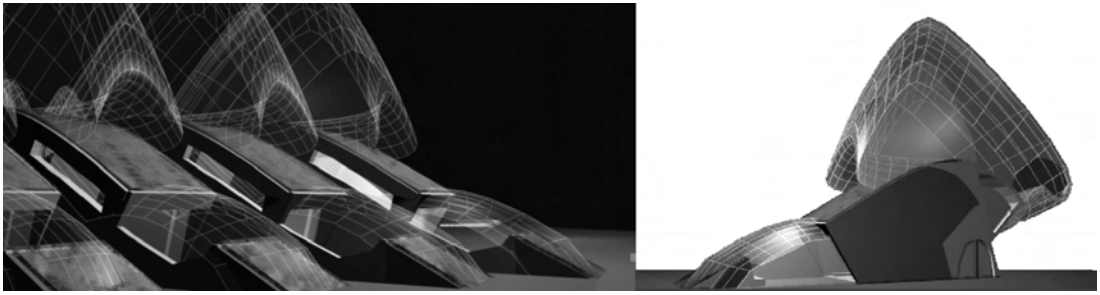


Figure 6: Images from the dormitory portion of the Planetary Collegium project. On the left is a berm-structure consisting of individual dorm units, one of which is on the right. The grey volumes represent zones in which virtual objects may appear after construction. The volumes were developed at the same time as the actual living spaces.

media equivalents. Corroboration distinguishes cybrids as compositions rather than mere aggregations of effects, a subject addressed in Principle 2.

The Caltech offices and the robot best demonstrate the corroboration principle. The mirrors of the office suggest the virtual space of the company, a space that will eventually be accessed through a three-dimensional online domain (Figure 7). Conversely, if you should visit this domain, you would enter the physical part of the office through the mirrors. In this way the mirrors play the role of windows or doors depending on whether the space is visited physically or online. The online experience is corroborated by what we see in the physical space, and vice versa.

The robot employs two ultrasonic sensors and an on-board processor. The sensors are effectively the eyes of the robot and together with the processor determines the distance to the walls and other objects (Figure 8). However, in this case, the sensors are used to define the virtual component of the cybrid, an invisible, roughly triangular blimp shape in front of the robot (Figure 9). The stereo-optic placement of the sensors lets the robot know whether the virtual object is being pushed, pulled or nudged side-to-side. The physical robot responds as though the virtual element were a material part of the machine.

This response is confirmed by the use of a mixed reality software program, *ARToolkit*, designed by Mark Billinghurst and Hirokazu Kato. Operating on a separate computer this software lets users see the invisible shape along with the robot. In this case corroboration of the virtual element occurs at a number of levels: (1) that of the two sensors and processor together define the blimp; (2) the motion of the robot in response to 'touching' the virtual object; and (3) the ability to see the blimp and robot using ARToolkit. Corroboration lets us assemble these impressions into a cybrid whole, the robot and its invisible object.

4. Reciprocity: Reciprocity between a cybrid's physical and cyber spaces allows actions in one domain to affect the other.

Reciprocity concerns the behaviour of the composition – the integrity of the cybrid – rather than its supporting technology. An example of weak reciprocity would be the one-way correspondence between CAD files and the actual building they specify. This is a weak coupling because the relationship

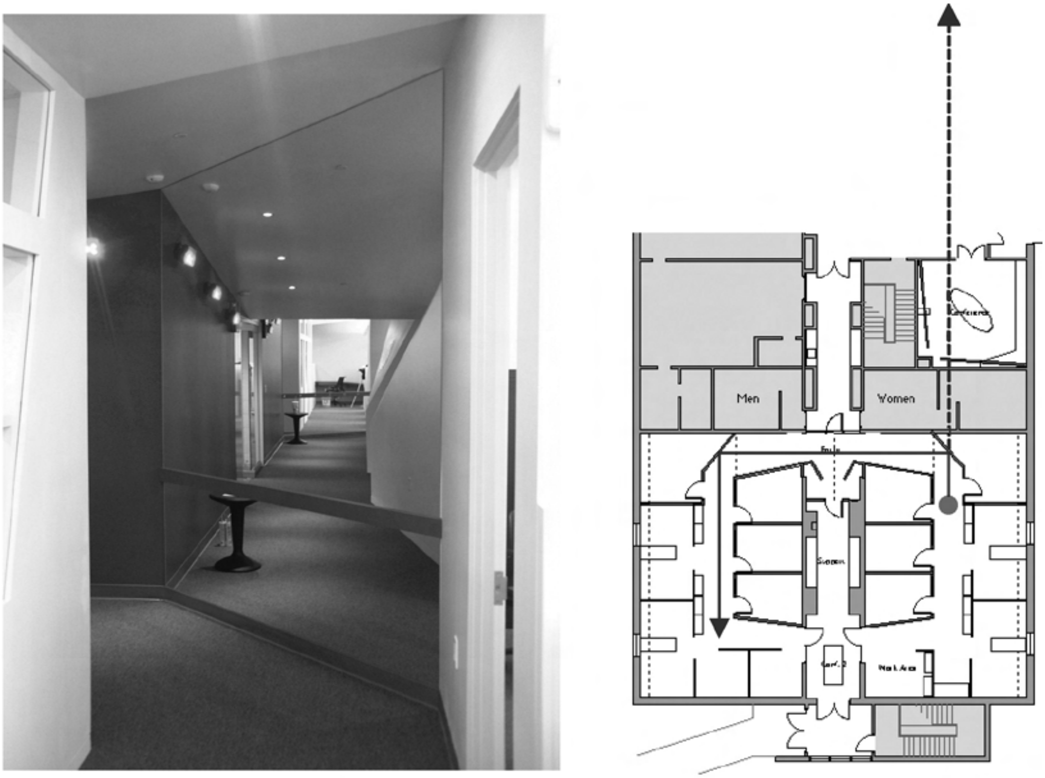
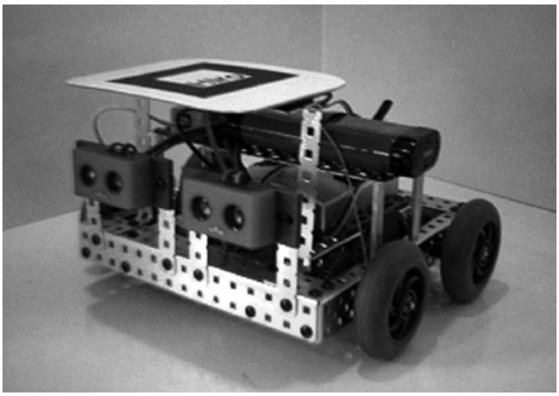
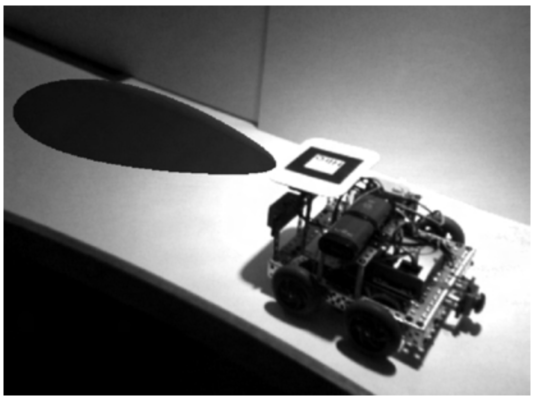
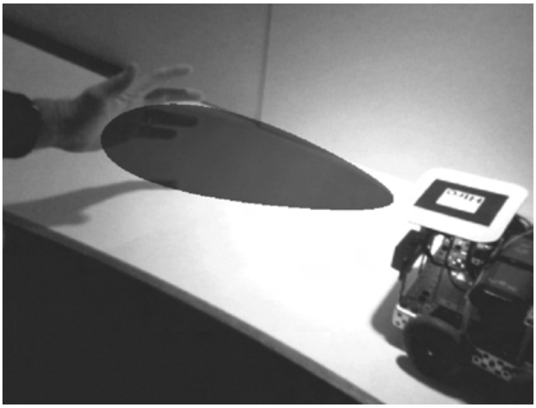


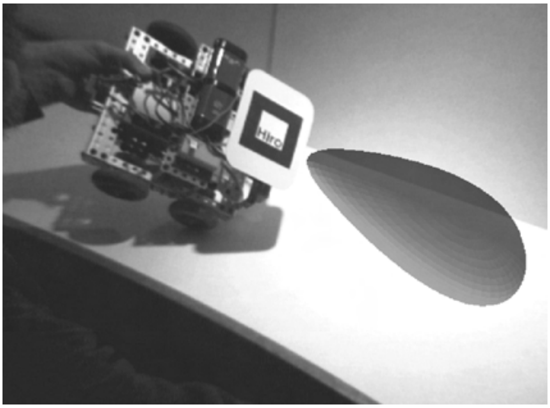
Figure 7: On the left is a view through the entry of the office space. The key plan on the right shows the location of the camera (red dot), indicating the reflected light in the mirrors (blue line), and the illusion of a virtual space beyond (dashed blue line). This virtual space is part of the overall cybrid space of the design (see Figure 5).





Figures 8 and 9: The robot has two ultrasonic sensors that detect distance. The cardboard top of the robot has a fiduciary icon used by ARToolkit to locate the virtual component. The oblong shape shown on the right is the virtual part of the cybrid. It is three-dimensional and maintains its location with respect to the robot as though it were a physical element of the composition (see Figure 11).





Figures 10 and 11: These images show how the physical and virtual parts of a cybrid act reciprocally. Pushing or pulling on the virtual portion causes the physical robot to advance or back up. Manipulating the physical robot affects the virtual object as well as seen on the right.

between them is barely reciprocal – if at all. Changing the CAD file does not affect the building or vice versa. The playhouse and office space are good examples of weak reciprocity since the virtual and physical components – to this point – do not interact beyond being parts of the composition.

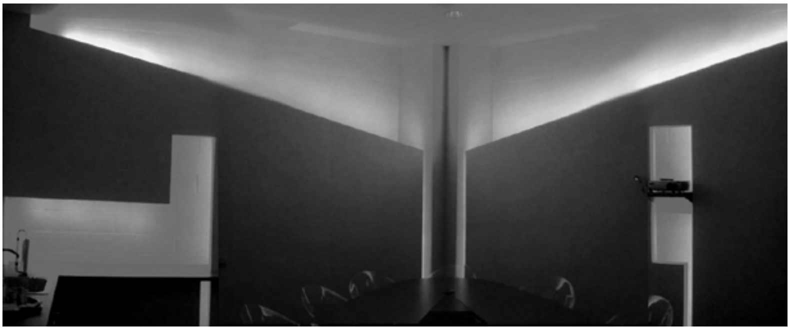
Strong reciprocity requires a tighter coupling between material and cyber spaces so that change in one state affects the other. Current examples would include monitoring/control systems, surveillance and building operation networks.

The images above show strong reciprocity between physical and virtual components (Figures 10 and 11). Actions on the virtual element affects the physical – 'pushing' on the blimp causes the robot to move back. Conversely actions on the physical, say lifting or turning the robot, causes the blimp to move as though it were part of the machine.

5. Extension: Cybrids provide users with a coherent spatial environment that extends their awareness beyond the concrete world to a dimensionally rich, mediated space.

This principle addresses the spatial qualities of the cybrid and the ability of users to generate spatial experience from a variety of informational sources. Users who can, for instance, see the virtual blimp, know the set range of the ultrasonic sensors. In this way their senses have been extended to include an ultrasonic frequency, if only through the corroboration of technology and the users' innate ability to spatialize information.

Sensory extension is an important motivation for AR research. Grant Foster and his colleagues at the University of Reading and, later, Steve Mann of the University of Toronto have used augmented reality to make hot areas visible to users (Foster et al. 1998; Mann 2002). The use of augmented reality to detect invisible objects has also led to systems that can be used in fighting fires, surgery and locating objects in murky water (Giannitrapani et al. 1999; Bimber and Raskar 2005). In these cases the users' senses extend beyond their normal range through mixed reality technology.

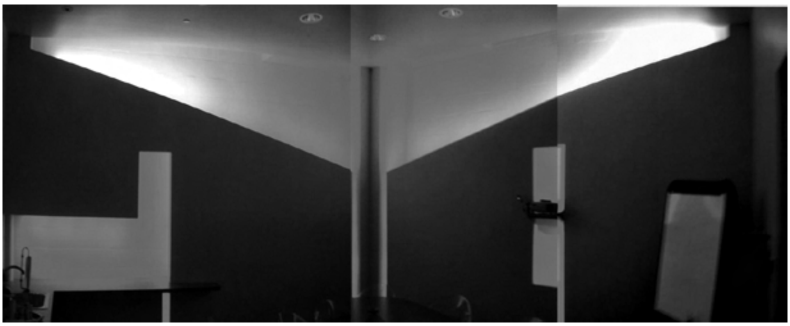


Figures 12 and 13: These images show LED lighting in the office conference room (left) and the entry way. Colours in the spaces go through a full rainbow cycle in one hour in the conference room, over eight hours at the entry. The two spaces are coupled through motion detectors and shared processors.

6. Social context: Cybrids provide an extended social space

If by *invisible objects* we also include remote entities, we open the door onto the sixth principle, social context. Architectural cybrids may form social spaces that integrate physical and cyber spaces. Beyond sustaining the activities of its occupants, cybrids may provide telepresent users with a context for interacting with physical occupants. This was the intention behind the design for the Planetary Collegium project, the office space and the playhouse.

Of the three projects, virtual presence is only manifested in the office space. Sensors and processors in the conference room and entry activate LED lighting in the counterpart space (Figures 12 and 13). For instance, if the conference room is occupied, the lighting changes colour in the entry hall. Conversely, if someone is in the entry hall, the colour of the conference room lighting changes subtly (Figures 14 and 15). It was originally thought that visitors to the company website would affect the lighting in the entry hall as well, effectively *haunting* the lobby via cyberspace. Although this feature has not been realized, it suggests historical/anthropological models for interaction with non-physical presences. Future interaction might be based on myth, legend or even occult practices.



Figures 14 and 15: Visitors in one space cause a slow, spreading cloud of white light in the other space. These images show the lighting in each space with the moving cloud. The effect lasts about ten seconds before fading away.

7. Anthropic design: Cybrids shall be designed to augment their users' innate use of space to think, communicate and experience their world.

Anthropic cyberspace has been defined as 'an electronic environment designed to augment our innate use of space to think, communicate, and navigate our world' (Anders 1999: 9–10). The seventh principle expands upon this definition to include both the material and cyberspatial aspects of cybrids. While our first principle addressed the comprehensive space of the designer, i.e. the mental/virtual/physical space, this one does so for the user. The seventh principle stresses the way we make sense of the world through spatial experience. It recognizes space as a product and tool of consciousness, a medium shared by designers and users alike.

Conclusions

The principles and projects referred to above illustrate issues designers may encounter in a mixed reality project. Needless to say, designers have considerable leeway in how they apply the principles. As we have seen, a project's integration of physical and virtual components depends on design priorities, budget and the technologies involved. Of the projects shown, for instance, only the robot demonstrates strong reciprocity. Several of the projects still await fuller development of their virtual spaces – especially their social use.

The projects helped test the cybrid hypothesis and led me to some unexpected solutions. In building the robot I found that using two off-the-shelf processors and programs got me around having to specially develop integrated software for the cybrid. The robot's processor, for instance, handled motion detection and locomotion, while the laptop processor handled imaging. The two processors simply did their jobs without communicating with each other. The coincidence between motion and graphics 'integrated' the robot and virtual object in the mind of the observer. This inferred link between phenomena shows how important consciousness is in completing the composition. It appears that with advances in ubiquitous computing that similar redundancy of processors in our environment may have unexpected, magical effects.

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Neosentience – a new branch of scientific and poetic inquiry related to artificial intelligence

Bill Seaman and Otto Rossler

Abstract

Neosentience, a potentially new branch of scientific inquiry related to artificial intelligence, was first suggested in a paper by Bill Seaman as part of a new embodied robotic paradigm, arising out of ongoing theoretical research with Otto E. Rossler. Seaman, artist-researcher, and Rossler, theoretical biologist and physicist, have been examining the potential of generating an intelligent, embodied, multimodal sensing and computational robotic system. Although related to artificial intelligence the goal of this system is the creation of an entity exhibiting a new form of sentience. Its unique qualities will be discussed. 'Sentience' is not yet used in the formal languages of either cognitive science or artificial intelligence. Two related approaches are (1) the generation of artificial minds via parallel processing, in a robotic system; (2) an alternative approach is the generation of an electrochemical computer as a robotic system. Biomimetics, along with state-of-the-art computer visualization is employed. The electrochemical paradigm has a complexity that exceeds standard computational means. The scientific and the poetic elements of the project are motivated by human sentience. The sentient entity is initially modelled on our functional definition of human sentience. The system involves synthetic 'drives' as a new element. We seek to articulate the differences to living brains. This transdisciplinary approach necessitates different forms of inquiry to inform this project such as cognitive science including psychology, education/learning, neuroscience, linguistics, philosophy, anthropology, biology and the arts. We believe that this area of research to be of importance.

Keywords

Neosentience
(post) artificial intelligence
autonomous robots
endogenous drives
brain equation
artificial persons
universal simulator

Neosentience – a new branch of scientific and poetic inquiry

Central to both the scientific and poetics of neosentience is to try to abstract the salient qualities of the human self that contribute to the arising of sentience. What are those qualities and what functionalities lead to their arising? A unified approach is attempted including body, brain, mind, environment and language.

We examine[1] (Rossler, O. 1973a, pp. 342–69) the possibility of abstracting the functional biological systems at operation in the body that enable sentience to arise. We generate this biological abstraction by employing a set of coupled systems derived primarily through analogy to the functionalities of the human counterpart. We present an outline of both system

1. Seaman, working as an artist/researcher has explored the related topic of meta-meaning production as a poetic goal in his historical research. Informed and inspired by the ongoing research dialogue with Rossler, Cariani and others, Seaman has been creating a series of

classes and their operational functionalities. The goal is to re-see the body as a functional complex system exhibiting sentience. We abstract qualities from this bio-environment to create the neosentient entity. (Rossler, O. 1973b, pp. 546–82) In this light we see the body as a machine of the highest order of complexity nested in a larger environment.[2]

Although computers and the software/hardware paradigm are often compared to the mind/brain, the systems at operation in the human body are of a different order of complexity. The nature of the various inter-functionalities of biological processes are operational in a very different manner to that of the computer. We are interested in developing a new computational model that seeks to reflect how we function as embodied, multifaceted biological systems. This model takes into account how we come to know the world through the integration of time-based pattern flows (Seaman, B. 2005a) of multimodal sense inputs over time. While, historically, studies of the senses have been kept separate, we are interested in how the senses work together to generate situatedness and environmental understanding. Eventually language and creative functioning will be enabled. (Suchman, L. 1987)

Background

If we look at the history of artificial intelligence, one struggles to find a singular coherent definition of intelligence. Instead a pragmatic approach is usually undertaken that is summed up in the following quote by Aleksander and Burnett, drawn from their book *Thinking Machines – The Search for Artificial Intelligence*:

> Rather than becoming embroiled in the controversies which surround the nature of human intelligence, the practitioners of artificial intelligence have generally chosen to define their goals in empirical or operational terms rather than theoretical ones [. . .] The researcher simply chooses a task that seems to require intelligence (playing chess say or recognizing visual images) and tries to build a machine that can accomplish it.
>
> (Aleksander, I. and Burnett, P. 1987)

In the same spirit we consider a sentient robotic entity to be a system that could exhibit the following functionalities: it learns; it intelligently navigates; it interacts via natural language;[3] it generates simulations of behaviour (it 'thinks' about potential behaviours) before acting in physical space; it is creative in some manner; it comes to have a deep situated knowledge of context through multimodal sensing; it displays mirror competence. (Lorenz, K. 1977) (de Waal, F. 2006) We have entitled this entity the *Benevolence Engine*. The inter-functionality is complex enough to operationally mimic human sentience. Benevolence can in principle arise in the interaction of two such systems.

Central to the project is the relationship to human sentience. Biomimetics is a fertile area of study. (Bar-Cohen, Y. and Breazeal, C. 2003) By abstracting and rearticulating particular operational qualities of the body, we see a new form of sentience arise. We approach it by generating a network of analogies. In the paper 'Adequate Locomotion Strategies for an Abstract Organism in an Abstract Environment – A Relational Approach to

artworks/installations: a video tape with an extensive poetic text by Seaman – *The Thoughtbody Environment/Toward a Model for an Electrochemical Computer*; a series of photo/text images; a set of short Haiku-like techno/poetic texts – *The Thoughtbody Interface,* and the development of a proposal for a relational multimodal database to house both the scientific research surrounding this project as well as aspects of the poetic work[1]. Seaman is collaborating with D. Howe on a *Bisociation Engine* project as well. Thus deep art/science creativity is explored in the service of entertaining the problem by exploring diverse sensibilities, processes and methodologies.

2. In particular, electrochemical processes will be entertained related to research toward the Thoughtbody Environment in a subsequent paper.
3. Steeles, L., http://arti.vub.ac.be/steels/publications.html

Brain Function', Rossler, a long time ago, articulated a top-down approach that underlies the first functional implementation. The text describes a special 'equivalence class' of bio-functionalities. (Rossler, O. 1973a, pp. 342–69)

For the sake of playfulness, The N_S.E.N.T.I.E.N.T. paradigm embodies the following salient characteristics:

- **Neosentient**: the system seeks to exhibit sentience of a new variety; (we will elaborate below on how this machine-based sentience would be of itself, having different qualities to that of human sentience).
- **S**elf-organizing: the system is self-organizing.[4]
- **E**nvironmentally embedded: the robotic system should be situated and context aware and/or remotely connected to a situated multimodal sensing system.
- **N**ascent: the system is 'brought to life' and learns over time, building up a body of situated knowledge.
- **T**emporal: the system functions in relation to multimodal time-based flows of differing machine-oriented 'sensing' inputs, the parsing of those flows through pattern recognition and operations on those flows (internal abstraction).
- **I**ntra-active: the entity arises through a reciprocal forming with culture and interaction with other individuals. Intra-action may take place with other entities. Because direct input might be facilitated between 'entities' and/or in new forms of human/entity communication, I have used the prefix 'intra' suggesting a different order of connectivity in communication (distinguishing a property of neosentience). The system develops an ongoing 'projective' linguistics.
- **E**mergent: the entity's actions arise in context and are not known in advance but 'come to life' in relation to environmental relations, a series of 'emotional' force-field attractions and repulsions, and historical intra-actions.
- **N**avigational: it can move about to function in an appropriate manner and becomes context-aware across multiple domains.
- **T**ransdisciplinary: the research is informed by and informs multiple disciplines as it become emergently enfolded. As the entity becomes self-aware and learns, neosentience will also be something it leans about, and it may become a participant in its own discourse of becoming, furthering transdisciplinary discourse in a unique manner.

Diagram of the benevolence engine

The Benevolence Engine can be implemented through parallel processing (first in simulated form). We present a flow diagram of the system (Figure 1). This diagram has been composed, drawn from a series of previous papers.[5] One sees a series of functional parts that have been arrived at through the methodology of deductive biology. (Rossler, O. 1978, pp. 45–58) We list the main functional parts of the diagram:[6]

A. Poly-sensing input/multimodal sensing systems (Seaman, B., Verbauwhede, I. and Hansen, M. 2004)
B. Buffer/pattern matching mechanism
C. Virtual reality generator (Rossler, O. 1981b, pp. 203–09)

4. *Self-Organizing Systems (SOS)* http://www.calresco.org/sos/sosfaq.htm#1.1 2006, for a definition of self-organizing systems.

5. Rossler, O. 1973c, *Chemical Automata in Homogeneous and Reaction Diffusion Kinetics,* as found in *Lecture Notes in Biomathematics*, vol. 4, Levin, S. (managing ed.), *Physics and Mathematics of the Nervous System*, Conrad, M., Gottinger, W. and Dal Cin, M. (eds.), Springer-Verlag, Berlin, Heidelberg and New York. p. 417.

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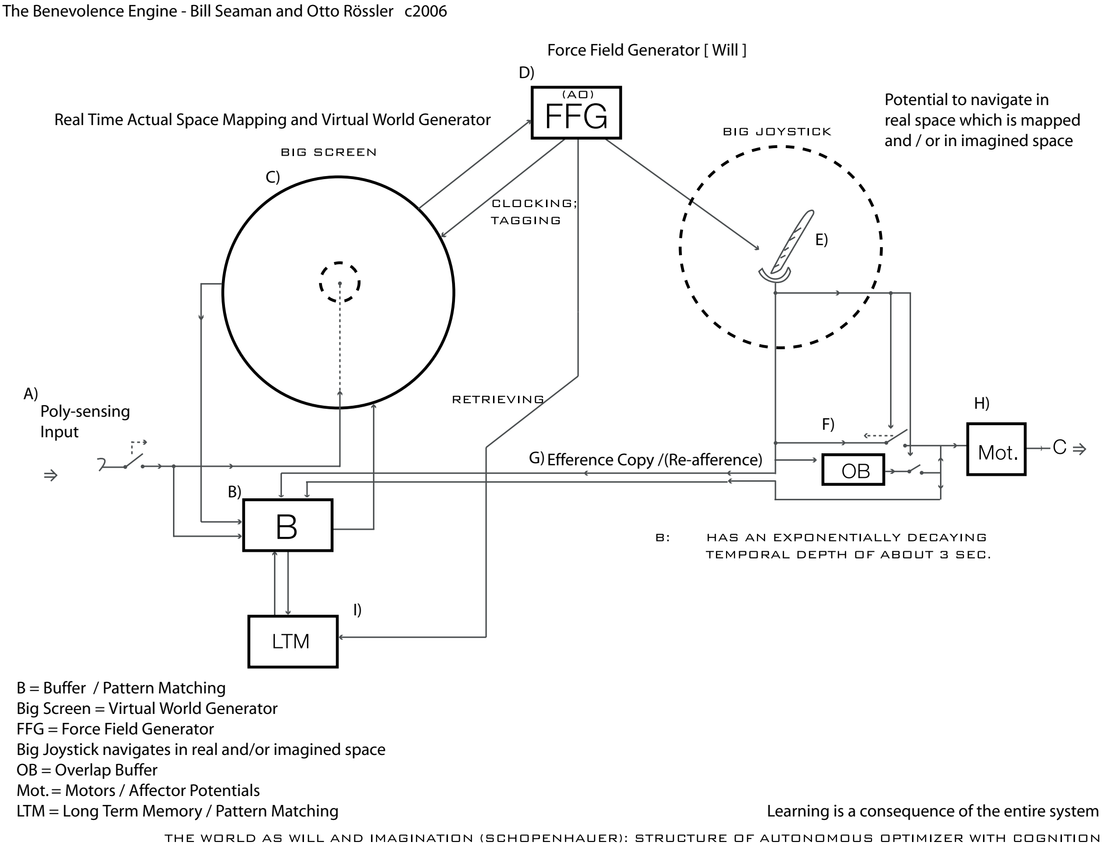

Figure 1: The Benevolence Engine/Schematic Working Diagram – Bill Seaman and Otto E. Rössler c2006

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D. Force-field generator (repulsion and attraction sliders) (Rossler, O. 1981a)
E. Control driver [internal joystick]/simulator mechanism (imagined space)
F. Overlap buffer
G. Efference copy/reafference[7]
H. Motor/motivation/movement potentials
I. Long-term memory

A. Poly-sensing input/multimodal sensing systems

The Benevolence Engine begins with a series of input devices – a machine-based multimodal sensing system.[8] One can imagine one's own senses being abstracted into such a mechanism, although machine-based sensing potentials will potentially be quite different in sensitivity to their human counterparts, i.e. one can imagine a system being implemented with infrared vision. Embodied multimodal sensing has been discussed by Suchman and Agre. (Suchman, L. 1987) (Agre, P. 1997) Such multimodal approaches were initially discussed early on (in the 1990s) by people like Brooks. (Brooks, R. and Stein, L. 1994, pp. 7–25) This represents a quite different perspective to earlier AI projects that were not 'embodied' and did not see the importance of coming to a deep knowledge of context via multimodal sensing systems that would be dynamically linked to their environment. Rossler's early papers are unique to the field of AI. Seaman's concept of 'Pattern Flows'

(Seaman, B. 2005a) is discussed in his paper 'Pattern Flows/Hybrid Accretive Processes Informing Identity Construction'. This paper points to the potentials of 'pattern flows' of sense inputs as a means of coming to understand meaning of production. L. Barsalou has conducted much research in this area. (Barsalou, L., 1999, pp. 22, 577, 660) So has Professor Charles Spence at the Crossmodal Research Laboratory, providing significant research into the nature of multimodal sensing.[9] Peter Cariani has also written at length about sensing and temporal codes.[10] Jon Bird and Andy Webster have also explored related electrochemical sensing topics.[11]

Multimodal sensing systems enable the transduction of sense data into a 'pattern language' the system can utilize. This represents a set of processes that contribute to the potential arising of neosentience. Synthetic senses can have different qualities to that of their human counterpart – there can be more of them and they can exhibit different sensitivities to that of the human. Thus the Benevolence Engine's 'phenomenological' experience would be *of itself* because the machine-based senses would give it a qualitatively different ongoing understanding to that of the human sensorial domain. Consider our understanding of the stars using human vision. Then consider our understanding of the stars after the invention of the telescope. We might also picture radical connectivity to devices like scanning/tunnelling microscopes. If a series of machine-based senses were the *normal senses* that functioned together to form an understanding of the world for the Benovlence Engine, its general perception of the world would differ from that of the human. One might argue that the same technologies function as extensions of our own senses, such that there would not be a difference. We believe the integrated use of multiple non-human sensing systems will contribute a different understanding of the world and thus help generate this state of neosentience – a sentience based initially (in part) on the abstraction of human sensing. Our system would contribute to coming to know the world in a unique manner.

B. Buffer/pattern matching mechanism

The system would observe in a form of foveal 3Don to vision,[12] define an updateable map of the environment (by abstracting and simplifying the input), generate a virtual environment that can later be drawn upon for pattern recognition purposes as well as to enable a correlate of 'closed eye vision' for navigation of imagined spaces before acting in physical space.

If we think of a human acting in physical space we perform within a layered topological space[13] (Lewin, K. 1936, p. 54) by superimposing our human emotional space (our feelings, attractions and repulsions to situations and needs) on to physical space. Emotional space and physical space can be conjoined or can be contemplated before action is undertaken. This forms a topological/psychological space where many factors (other parts of the system) play into the 'understanding' and 'parsing' of sensed stimulations/environmental difference. We 'build up' knowledge and use it in a projective manner, informing the understanding of incoming data. A goal of the system – meaning acquisition through 'pattern flows', will enable the entity to form new understandings through learning and creative combinatoric pattern reapplication. Each individual sensed aspect of a linked set of multimodal memories can lead back to the memory of the original pattern

Seaman, B. 2005a, 'Pattern Flows/Hybrid Accretive Processes Informing Identity Construction', *Convergence Magazine*, Winter.

Seaman, B., Verbauwhede, I. and Hansen, M. 2004, *The Poly-sensing Environment and Object Based Emergent Intention Matrix: Toward an integrated Physical/Augmented Reality Space*, http://students.dma.ucla.edu/~fwinkler/PSE/.

6. Seaman, B. and Rossler O., Toward The Creation of an Intelligent Situated Computer and Related Robotic System: An Intra-functional Network of Living Analogies, http://billseaman.com/
7. Hopkins, C., http://instruct1.cit.cornell.edu/courses/bionb424/students2004/jlf56/general.htm
8. See also MEMS – Micro-Electro-Mechanical Systems (MEMS), http://www.memsnet.org/mems/what-is.html. See also Seaman, B., Verbauwhede, I. and Hansen M. 2004, http://students.dma.ucla.edu/~fwinkler/PSE/ for an environmental approach.
9. http://www.psy.ox.ac.uk/xmodal/
10. http://homepage.mac.com/cariani/CarianiWebsite/CarianiHomePage.html Cariani has also shown his interest in Pask's electrochemical studies. Cariani and I have spoken at length about these topics.
11. http://www.andywebster.info/

(or constellation of multimodal inputs) through pattern matching. The system would potentially generate 'Platonic' simplifications (von Forester, H., 1962) or averaging[14] – enabling potential recombinant collage-like 'creations' built of past relations, mixed with updated information and language (both patterns in their own right).

C. Virtual reality generator

The entity is embodied and embedded in the environment. Multimodal senses provide deep knowledge of the environment that is built up slowly through learning and the inter-functionality of the differing branches of the system functioning over time. A virtual picture of the environment is being built up in real time. The memory of this picture becomes abstracted by the system. High-resolution storage of all situations over time is not 'economically' viable for the system with a finite memory space. The system 'experiences' in high detail, with foveal focus shifting across individual senses and multimodal 'relational' centres. The entity builds up averaged patterns through simplification/abbreviation/metonymy (platonic reference) through the averaging of patterns. The virtual world also stores comparative relations to other correlated time-based sense data. Memory becomes a relational configuration over time (See O'Keefe, J. and Nadel, L. 1978) and depends on the environment for filling in many details for actual embodied experience. (Clark, A. 1997) Multimodal sensing contributes to this relational time-based configuration. The density of detail of this relational set is also decreasing in resolution over time (related to the image content/virtual mapping that is stored) although aspects of the resolution can be built back up with subsequent emulation/simulation and/or new encounters with similar but different things, updating based on new data, and additional encounters with the environment. A neosentient approach suggests that this 'mind eye' can be shared with other entities, networked and/or made visible in a public manner. Thus again, the Benevolence Engine's mind's eye will be significantly different in nature to that of the human. Humans cannot share their mind's eye's vision in a direct manner. (de Chardin, T. 1955) (Ascott, R. 2003) Yet in seeking to posit such a new vision system, one must come to study the functionality of the human visual system, and its relation to other sensing systems in the body in a manner that transcends contemporary science's need to isolate sensing systems – the visual system in particular. Thus new forms of multimodal research must be undertaken and/or abstracted to help us comprehend the inter-functional nature of senses especially in terms of pattern matching and memory retrieval.

D. Force-field generator (repulsion and attraction drives)

We must remember that human emotion and human need (drives) play into many of the spatial decisions we make – our human behaviour. Again the topological/psychological space of Lewin is evoked. A series of 'drives' (internal emotional forces) suggest for us the need to approach and/or avoid differing situations. Our system would house a series of force-field sliders that would sum in differing ways related to alternative situations (as well as historical input that is re-associated with the current context through pattern matching, conjoined with current environmental input). This posits a complex systems approach leading to particular behaviours

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12. See the following related systems http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=546136 and http://hal.inria.fr/view_by_stamp.php?label=INRIA&action_todo=view&langue=fr&id=inria-00074004&version=1 and more recently http://www.informatik.unitrier.de/~ley/db/indices/atree/w/Walther:Marcus.html

13. Lewin writes that one can potentially join multiple differing topologies together – topological psychological spaces, simulation spaces and physical/actual motion spaces. Lewin discusses how a series of psychological vectors might form a topology. In the chapter entitled 'The Psychological Life Space as Space in the Sense of Mathematics', he describes how psychological facts can be articulated, 'connected' and 'coordinated' in a topological space, forming paths – 'any kind of locomotion of the person in the quasi-physical, the quasi-social, or the quasi-conceptual field can be designated as a connecting process which corresponds to a topological patch'. Lewin further provides remarks about topological space: 'The fact that certain regions in the psychological environment and within the person influence other regions, both of the environment and of the person, may be taken as a criterion for connectedness in the topological sense.' This happens through

over time. The force-field sliders are quantifiable in machine-oriented terms, and controllable/programmable and thus again present a difference between neosentient entities and humans. A neosentient entity might also be empowered to internally re-set their own force-field sliders.

'dynamical communication.'

14. Conversation with Jim Davies.

E. Control driver [internal joystick]/simulator mechanism (imagined space)

This part of the system both steers the behaviour of the mechanism (joystick metaphor) and/or performs simulations of what steering the mechanism might accomplish (again related to closed eye vision) or picturing your behaviour before you do it to help make decisions (simulation space). Alternatively this sends messages to robotic effectors to bring about movement in actual space.

F. Overlap buffer

The overlap buffer enables the entity to be performing in actual space while simultaneously running simulations (imagined spatial relations) that help the entity make decisions about how to act in that space. They thus can focus on the actual view, the imagined view or a simultaneous mixture. This correlates to the human's ability to close their eyes and just think about a situation, and/or think about it (or other spaces) while simultaneously acting in an environment.

G. Efference copy/reafference

This is based on von Holst's Reafference Principle. A control system (the brain) or in this case a computer, has sensory and motor connections to muscle-like effectors. The efference command is the motor command. The reafference is a 'sensory' response from the motor. The reafference and the efference copy interact. If these are of equal magnitude and opposite signs, they will cancel each other out. If the afference is larger or smaller than the magnitude of the signal in the efference copy, the signals will not be cancelled out, and the difference between the efference copy and the afference will be transmitted to the control mechanism. (Mittelstaedt, H. 1961, pp. 246–54) (Holst, E., and Mittelstaedt ,H. 1950, pp. 464–76) Thus, the 'exafference' forms a relational connection with the entitie's motion and/or behaviour within the environment and the entity's pattern matching, control and simulation mechanisms.

H. Motor/motivation/movement potentials

All of the systems functioning as a unity define the potential of movement that is directly linked to the environment through the multimodal sensing system, and the knowledge that has been built up concerning the environment over time.

I. Long-term memory

Long-term memory stores particular patterns for long periods of time which are also slowly decaying or losing resolution (in terms of image-based patterns). Thus current pattern matching in the initial buffer enables the entity to do pattern matching with past environmental patterning.

Discussion

An artificial mind was proposed. It combines many functional ingredients that apparently have not been proposed before, either alone or in combination. The 'big screen ' is a fully fledged virtual reality in the sense of William Gibson. (Gibson, W. 1984) There is an updating involved that automatically generates a natural frequency of 'nowness' regeneration. It would not make sense to have an updating rate that is much faster than locomotion and limb movement requires. The forces that emanate from source points in the spatial environment are represented on the 'big screen'. These forces control the locomotion of the artificial organism in concert with the programmed 'drives'. This is done via the 'big joystick' that is directly 'pulled' by force centres in the environment. The machine would be completely automatic were it not for the capability of closed eye locomotion. Here, the clash of some simultaneous forces acting on the joystick immobilizes it momentarily, while giving control to a simulated mode of locomotion. As soon as the simulation leads to a resolution of the conflict, the lower-level joystick takes over again. In this way, the machine is continually on the move, being under absolute control of the time-dependent forces exerted by 'sources' in the environment. There is consciousness involved.

But, if two such machines interact in a cross-caring manner, each can be stopped in an attempt to simulate in favour of the other's goals. In this case, the invention of an 'hallucinated other centre of optimization' occurs. This is the invention of 'benevolence'. This presents a much more interesting mode of functioning of the system than simple locomotion. It will be necessary to build two such machines to enable such coupling to completely understand the emergence of foreign controlledness within the system, along with its stopping to function as a subconscious optimizer. Actually the invention of the subconscious by Freud corresponds to the rediscovery of the old lack of consciousness mode in the brain. The real surprise is the emergence of a conscious giving up of the original unconscious identity through the emergence of a simulated existence that is benevolent, towards another simulated consciousness, also internally represented by the same system. So strangely, consciousness is not implied in the machine itself but only in a kind of paranoic creation out of nothing within the machine. The ghost of consciousness has no substratum in the hardware or software of the system. It is pure fiction but it is the only agent to be found.

We apologize that we have run ahead a little bit in the description of the system. Once the machine is ready for inspection and observation in interaction with another machine or a human partner, more details about its secrets will become available. The above interpretation of our machine presupposes to some extent that the reader is familiar with the descriptive work of ape psychology found for example, in the recent book *Our Inner Ape* by Frans de Waal.

Summary

Neosentience is a new area of scientific research. It operates out of a rich series of interrelated research agendas. We have presented the initial plan for a model to address the potential of having neosentience arise through a series of inter-functional processes that have been derived through careful abstraction from evolutionary space-dependent survival scenarios. It must be noted that any sentient entity that might be generated, modelled on our functional/operational definition of sentience, would have a set of qualities foreign to human sentience. In particular, the differences would be related to qualities of embodiment, sensing, communication channels, networking and the synthetic drives. Instead of ignoring the differences between a 'sentient machine' and human sentience, we seek to articulate these potential differences clearly. Articulating the operative nature of neosentience is related to invading neighbouring fields like psychoanalysis and ethics, not to mention the art of imagining other souls. (de Waal, F. 2005)

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Integrative art education in a metaverse: ground<c>

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Abstract

Virtual learning environments (VLEs) present us with unprecedented opportunities in bringing together students and educators from widely disparate geographical locations, as well as diverse cultures and backgrounds to participate in a learning experience that should take into cognizance the affordances of these novel arenas in the design of both content and the environment(s) in which this content is to be implemented/enacted. While VLEs do seem to address the requirements of well-structured learning endeavours, the boundaries of which are clearly defined, they are challenged where complex learning material in which boundaries are less easily defined, as is the case in art/creativity education, are concerned. Given that the learning content of the creative fields is 'open ended' by its very nature and as such does not seem to readily lend itself to an implementation within the structure of present-day, two-dimensional virtual learning environments, can such an environment/methodology be developed in the open-ended three-dimensional structure of a metaverse, based upon the critical examination of a real-life, historic precedent?

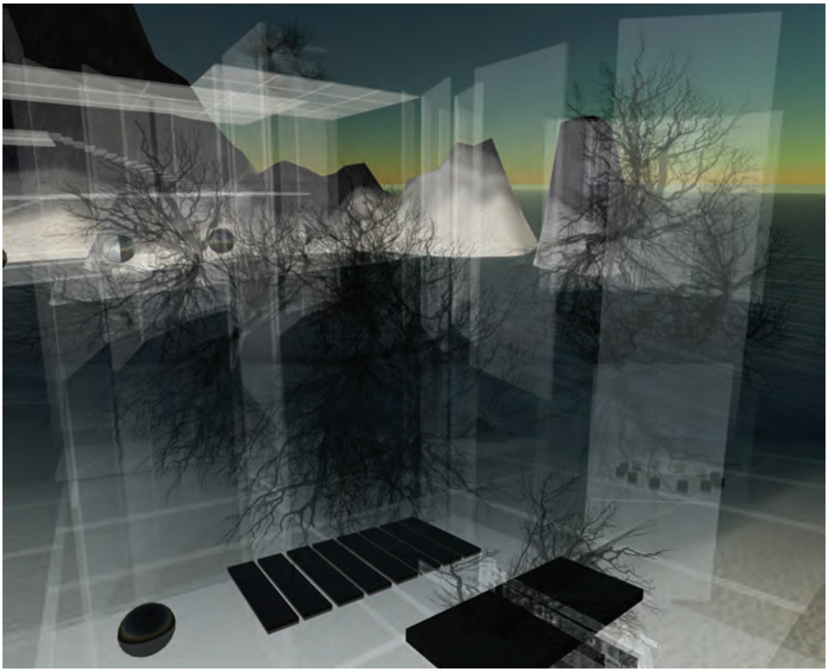
Keywords

metaverse
groundcourse
virtual learning environment
virtual design/architecture
avatar
role play

Introduction

'ground<c>' is an environment for art education, situated in the metaverse of 'Second Life', inspired by '"The Groundcourse"' (Ascott and Shankin 2003: 102–07), Roy Ascott's educational methodology developed and practised in England during the 1960s, the aim of which was to shake up preconceptions and behavioural patterns through exercises, games, role play and the implementation of educational 'irritants', in accordance with constructivist/experiential learning theories and cybernetics. McPherson and Nunes (2004: 46, 47, 54–60) propose that the design of online learning environments should be based upon sound pedagogical models, appropriate to a specific educational scenario. For ground<c>, this pedagogical model is the Groundcourse, a methodology, which through the emphasis it puts upon behavioural change as an approach to the enablement of creativity, especially through the enactment of new personalities, i.e. role play, is deemed to be particularly suited to the present quest of the author vis-à-vis the proposed realm of implementation, i.e. the metaverse.

Beyond these, much new ground has been added to the theoretical framework: while still adhering to the tenets of experiential learning and cybernetics, both of which were pivotal to the educational theory of the Groundcourse, ground<c> will also aim to incorporate educational theory



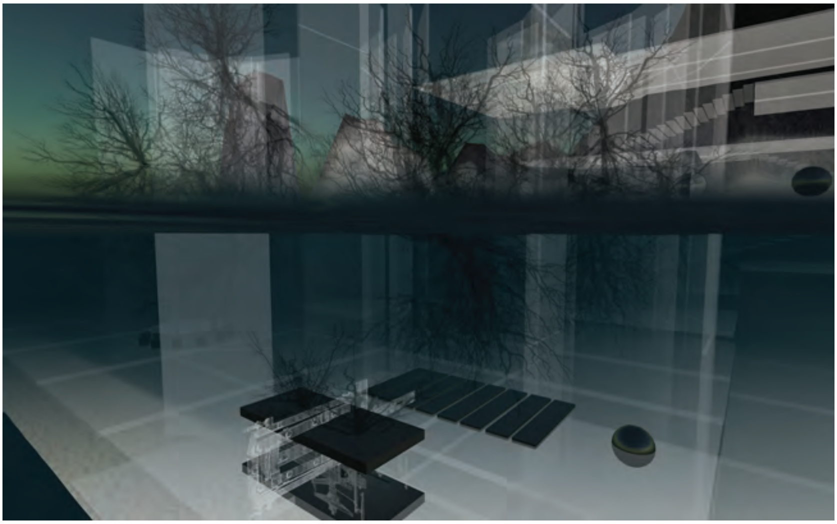


Figure 1: amphibian architecture (both) Screenshots of architectural experimentation utilizing the ocean and land of Second Life.

that has been formulated between then and now. First amongst these is an examination of electronic education today. However, two recent developments in adult education, namely transformative learning and constructionism, will also be examined and incorporated into the formulation of the educational methodology of ground<c>. Since the environment will be situated in a metaverse, taking full advantage of all the attributes of a metaverse, research areas pertaining to the metaverse, particularly cyber-psychology, will also be made use of in the formulation of learning content.

William Mitchell (2000) makes a strong case that the disciplines of urban planning and architecture must encompass virtual spaces as much as physical ones. But Mitchell also goes on to point out to what extent this global network is likely to change urban spaces altogether. While he discounts the likelihood of urban hubs disappearing altogether, Mitchell nonetheless foresees a dramatic shift from urban hubs to suburban or indeed rural nodes; a world where these nodes and hubs are so strongly interconnected through telematic channels that physical location will indeed become increasingly inconsequential. Strong, local node/neighbourhoods, active on a 24-hour basis, due to the demands of global connectivity and servicing the needs of increasingly home-employed populations will become increasingly the norm of everyday activity across the globe.

However, the shift in lifestyle and location is not the only one that needs to be taken into consideration. Many issues ranging from identity, including the facility with which it can be concealed in the virtual realm, to cultural diversity and linguistic barriers need to be considered at length. ground<c> will need to take all the problems that this novel telematic condition imposes on board, while at the same time reaping its countless benefits.

Following the theories of John Dewey (1921) regarding the importance of the physical environment as a crucial part of the learning process itself, much thought has been given to the actual format or physical domain/manifestation of ground<c>. That the metaverse, with all her built-in elements of unpredictability, of play/role play, of high levels of social interaction was an eminently suitable platform was decided upon, after two-dimensional as well as three-dimensional standalone applications were deliberated upon. The project is a design project, the output of which will be a virtual construct generated by the requirements of the underlying educational system. In the case of ground<c> this content is the educational methodology to be implemented, which will emerge through background analysis in the many diverse areas described below. What will be gathered from this background will subsequently be formulated into a brief upon which the requirements of the actual design, both methodological as well as structural, will be based.

The precedent

Combining cybernetics and constructivist educational theory, the Groundcourse (Ascott and Shanken 2003: 46, 47, 54–60) devised a flexible structure, 'within which everything can find its place, and every individual his way'. The outcome was a two-year art foundation course, the aim of which was to create an environment which would 'enable the student to become aware of himself and the world, while enabling him to give dimension and substance to his will to create and change', achieved through a drastic breaking-down of preconceptions related to self, art and creativity. Thus the operative tenet that was employed was one of providing an environment that fostered the rethinking of preconceptions, prejudices and fixations with regards to self, society, personal/social limitations, art and all the ensuing relationships through a carefully thought-out, coordinated and orchestrated range of assignments and exercises that entailed behavioural modification and indeed change.

One of the salient points of the methodology was that the student be instructed by active practitioners in their own fields and also that the faculty be large and of varied disciplines and backgrounds, ensuring multiple and diverse feedback loops in the educational process. Thus numerous painters, sculptors and designers as well as scientists were enlisted as faculty members who, in vivid interaction with not only the students but also with one another, formulated the wide range of exercises that spread over the two years.

The first year was devoted to countless exercises of creative problem solving, ranging from drawing exercises to the acquisition of artistic skills and perception; that could at times seem absurd, aimless, even terrifying. Empirical enquiry to precise questions was balanced by scientific study: irrational acts by logical procedures. At the core, however, was a concept of power, the will to shape and change, this indeed being the Groundcourse's overriding educational goal. Cybernetics and behavioural sciences were studied regularly. While the nature of drawing was re-examined, the values of perspective and mechanical and architectural drawing were practised and tested against problems of space. Natural growth and form were examined in the context of scale and reproduction, while other studies examined the modes of human perception. Students set about analysing and inventing games, logical propositions, idea sequences and matrices in which codes were designed and broken. Thus, 'in this first-year course, the student is bombarded at every point with problems demanding total involvement for their solution. Ideas are developed within material limitations and in the abstract. For the teachers, the formulation of problems is in itself a creative activity . . .' (in Ascott and Shanken 2003: 105).

During the second year of the Groundcourse the problem that students had to address was the task of acquiring and acting out a totally new personality, which was largely the converse of what they would consider to be their normal 'selves'. These new personalities were monitored with 'calibrators' that were designed to read off responses to situations, materials, tools and people within a completely new set of operant conditions. These responses were then used in the creation of mind maps to be utilized as consultational charts enabling a handy reference to behaviour patterns dictated by change in the limitations of space, substance and state. These 'new' personalities were asked to form hexagonal groups, which had the task of producing an ordered entity out of substances and space in their environment, with severe limitations on individual behaviour and ideas, forming the 'irritants', i.e. the educational aids of limitation in the pursuit of creative enablement. The irritation of the organism was applied in three different directions: towards the social relationship of the individual to his environment; towards the limitations implied in material situations; and towards conceptual possibilities.

> The groundcourse places the student at the centre of a system of visual education designed to develop in him awareness of his personal responsibility towards idea, persons and the physical environment such that he may contribute to a social context within which his subsequent professional activity may become wholly creative and purposive. The intention of the groundcourse is to create

> an organism which is constantly seeking for irritation. The term 'organism' may be applied to both the individual student and to the groundcourse as a whole.
>
> (From the prospectus for 1963/64 at Ealing College of Art and Design)

Students were then invited to return to their former personalities, making a full visual documentation of the whole process in which they had been engaged, searching for relationships and ideas unfamiliar to art, reflecting and becoming aware 'of the flexibility of their responses, their resourcefulness and ingenuity in the face of difficulties. What they assumed to be ingrained in their personalities they now tend to see as controllable. A sense of creative viability is being acquired' (in Ascott and Shanken 2003: 106).

The Groundcourse, with its pivotal emphasis on behavioural change as a founding tenet for the enablement of creativity, utilized the creation and enactment of new personalities as an educational process. This corresponds to the present-day phenomenon of role play in MMORPGs (massively multiplayer online role-playing games) and the metaverse. Research conducted in the emerging field of cyber-psychology also substantiates the importance of role play, the acquisition of alternative characters and indeed the acquisition of many alternative selves in the engenderment of behavioural change not only within the virtual environment itself but also, by extension, in real life. Beyond role play, the importance of playful activity itself as well as the building of concrete objects, i.e. toys, in the development of creative thinking, as proposed by Papert, is yet another key concept that can be adapted with facility to the fundamental premises of the Groundcourse's methodology. Thus, it is the position of the author that much insight and benefit can be attained from a critical examination and subsequent adaptation/reinterpretation of the Groundcourse's educational philosophy and premises as a pedagogical model aiding the enablement of creativity in a metaverse.

Transformative learning and constructionism

Although the Groundcourse does constitute the pivot of interest for this study, much new ground has been added to its theoretical framework. While experiential learning and cybernetics were pivotal to the educational theory of the Groundcourse, ground<c> will aim to incorporate educational theory that has been formulated between then and now. First amongst these is an examination of electronic education today. However, two recent developments in adult education, namely transformative learning and constructionism will also be examined and incorporated into the formulation of the educational methodology of ground<c>.

Transformative learning, which specifically addresses adult education and lifelong learning, is a process of getting beyond gaining factual knowledge alone to instead become changed by what one learns in some meaningful way. It involves questioning assumptions, beliefs and values, and considering multiple points of view, coming out of Jack Mezirow's earlier theory of perspective transformation. In theorizing about such shifts, Mezirow proposes that there are several phases that one must go through in order for perspective transformation to occur: 'Perspective transformation involves a sequence of learning activities that begins with

Figure 2: mountain Terraforming in Second Life: an integral part of metaverse architecture

a disorienting dilemma and concludes with a changed self-concept.' (Mezirow 1991, 193). While instrumental learning involves cause – effect relationships and learning through problem solving, communicative learning necessitates actively negotiating one's way 'through a series of specific encounters by using language and gesture and by anticipating the actions of others' (Mezirow 1991:78). The former is about prescription whereas the latter is about 'insight and attaining common ground through symbolic interaction' with other persons. For Mezirow, this is not a dichotomy but two distinct types of learning, both of which are utilized in many human activities.

Structuring the cybernetic art matrix in 1966 Ascott (in Ascott and Shanken 2003: 133–38) alerts readers to the emergence of 'a new, leisured class' that will be in search of creativity enablement and that falls outside of the boundaries of traditional art educational practice. The current phenomenon of creative participation and sharing via www2 domains seems to amply validate Ascott's early claim, who, in the Cybernetic Art Matrix, structured his learning system as a fluid, symbiotic construct within which diverse learner groups could be accommodated. ground<c> intends to follow this framework by specifically targeting non-professional practitioners of creativity as one of the learner groups. Thus Mezirow's educational theory, given that it does indeed specifically address the issue of lifelong learning, is considered to be a relevant component of the theoretical backbone of the project.

Seymour Papert's constructionist learning (Kafai and Resnick 1996: 11) is inspired by constructivist theories, as well some of the cognitive theories of Jean Piaget. Learning, according to Papert, is an active process wherein learners construct mental models and theories of the world around them. Constructionism holds that learning can happen spontaneously when

Figure 3: search-rescue The Metaverse: Play. A quixotic game of searching for and rescuing "avatars in need".

people are engaged in actively making things. Unlike Piaget, for whom it is a mere stage that the infant outgrows in due course of time, Papert places great value on concrete thinking – i.e. thinking with and through concrete objects – as a mode of thinking that is complementary to more abstract, formal modes of thought. It is a grave mistake, in Papert's view, to forsake or cast off concrete thinking, in favour of purely abstract thought. Constructionism is a way of making formal, abstract ideas and relationships more concrete, more visual, more manipulative and therefore more readily understandable.

Some of the research on which 'Serious Play' is based has been charted into basic concepts such as play and identity, while the goals of the method are listed as social bonding, emotional expression, cognitive development and constructive competition. Within this context play is defined as 'a limited, structured, and voluntary activity that involves the imaginary. That is, it is an activity limited in time and space, structured by rules, conventions, or agreements among the players, uncoerced by authority figures, and drawing on elements of fantasy and creative imagination' ("The Science of Lego Serious Play", 2002), involving storytelling and metaphor. Emotions such as love, anger or fear shape the different forms of play in which a player engages, as well as the symbolic expressions the player produces. Since play involves the capacity to pretend, and to shift attention and roles, it provides a natural setting in which a voluntary or unconscious therapeutic or cathartic experience may take place (*Science of Lego Serious Play* 2002).

The metaverse

The term 'metaverse' was coined by Neal Stephenson in 1992, in *Snow Crash*, where real world events are mixed with events that take place in a mass-visited communal virtual world, in which individuals can interact in a three-dimensional landscape by creating avatars. Each avatar is visible to

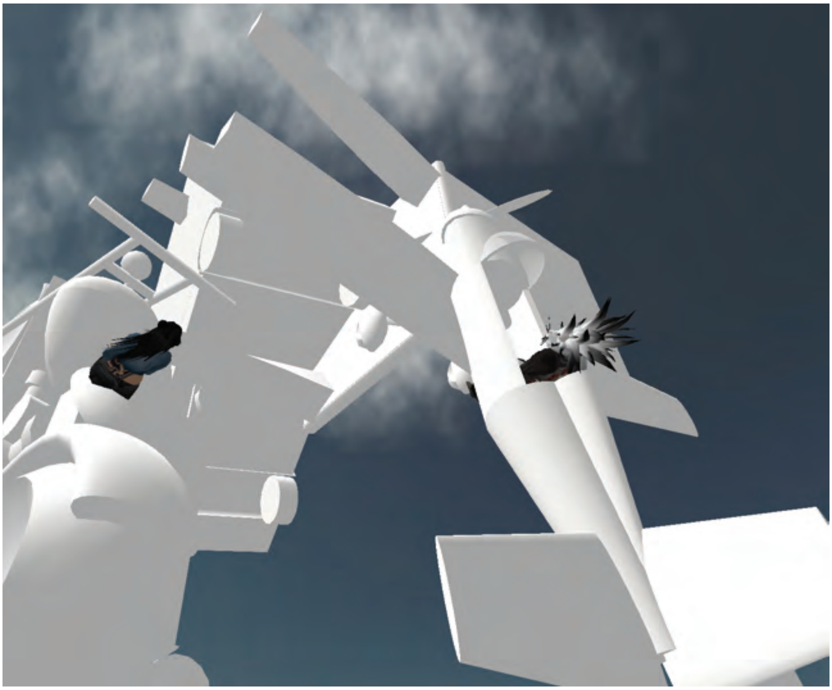


Figure 4: the-carousel The Metaverse: Play. Artistic practice and play often merge. Avatars Alpha Auer and Mosmax Hax break into spontaneous play, transforming components of an art installation into a makeshift carousel.

all other users, and avatars interact with each other in this communal virtual space through software-specified rules. The metaverse uses the metaphor of the real world, but without its physical limitations (Dodge and Kitchin 2000).

What differentiates the metaverse from online role-playing games is that, unlike games, the metaverse has no intrinsic rules that are game related: there are no scores to be gained, no levels to be attained. However, metaverse activity can be thought of as a game on a very basic level: these are unstructured virtual environments where characters undertake activities for the purpose of personal enjoyment, i.e. play. But, ultimately, they are virtual realms within which real-world rules, such as business acumen, social skills, work, creativity, learning, as well as beauty, eccentricity or charm – to mention just a few – are the keys to success. Unlike the real world, however, metaverses allow their residents the ability to fly, to teleport, to change gender or even adopt non-human forms and indeed the ability to switch back and forth between these different persona.

Cyber-psychology/the avatar

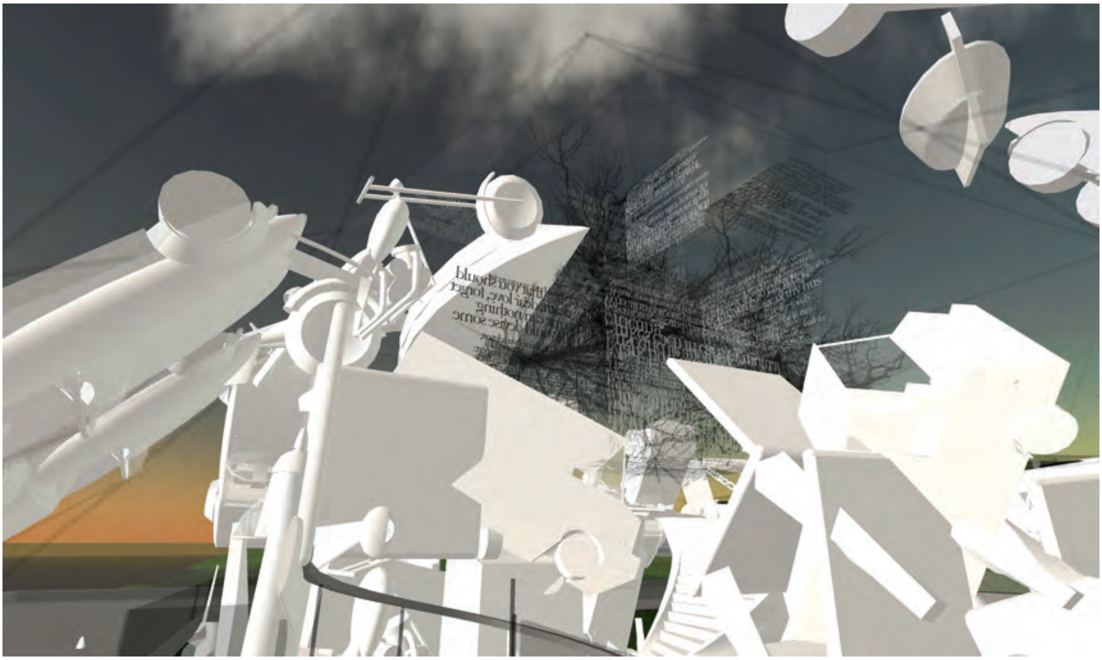
Avatars play an important role in structuring social interactions, as their inhabitants both consciously and unconsciously use them in ways very similar to their material body (Damer 1997). While the basic avatar is a human of either sex, avatars can have a wide range of physical attributes, and may be clothed or otherwise customized to produce a wide variety of humanoid and other forms. Avatars may be completely creative or representational. Furthermore a single person may have multiple accounts, i.e. 'alts'. Also, a single resident's appearance can vary at will, as avatars are very easily modified. Given that they visually portray an inhabitant and allow visual communication, Suler (1997) contends that avatar appearance is crucial for identity formation in virtual worlds. Avatars are able to move; they can manipulate objects, talk to each other and make gestures. Reid (1997: 197) describes them as a 'real person's proxy, puppet or delegate to an online environment'.

Research conducted by Yee and Bailenson (Yee 2007; Yee and Bailenson 2006; Yee and Bailenson 2007: 271–90; Yee et al. 2007: 115–121) verifies the profound nature of the relationship of the individual to his/her avatar. Studies on addiction, on whether the changes in self-representation that virtual environments allow individuals affect behaviour both in-world as well as in 'real life'; the motivations of participation and play, related to demographics such as age, gender and usage patterns; investigations into the benefits of embodied perspective-taking in immersive virtual environments; research into whether social behaviour and norms in virtual environments are comparable to those in the physical world all show that there is indeed ample material for implementing an educational methodology that embraces the breaking up of behavioural ruts due to preconceptions related to self, society and creativity through the realization and enactment of new personalities through the avatar.

Designing an environment for creative activity and learning

While the avatar can indeed prove to be a valuable learning aid in terms of acquiring new personalities and exposing the learner to assignments and experiments whilst enacting these new personalities, there will still remain considerable work to be accomplished in controlled situations and environments. The first year of the Groundcourse was devoted to exercises and assignments in perception, visual observation and analysis, drawing and building as well as lectures covering a range of topics from cybernetics to behavioural and cognitive sciences. ground<c> intends to follow suit in this regard. Thus environments and structures within which these activities can be accomplished need to be provided and these call for the formulation of a sturdy visual language that will engender a cohesive whole, a gestalt, as the actual design process begins to unfold.

John Dewey tells us that learning depends on two sets of conditions that enhance the nature of the learning 'experience' (Dewey 1997). First, the external i.e. controllable conditions, and second, the internal conditions/mindset of the student, which are inevitably beyond the control of the educator. Thus, at least one of the aims of any educational methodology aiming to develop and train minds is to provide an environment that does indeed induce such an activity. Dewey (1997) puts a high value on the design and structuring of the actual physical, educational as well as social environment and its operant components, indeed proclaiming that 'in last analysis, all that the educator can do is modify stimuli so that response will as surely as is possible result in the formation of desirable intellectual and emotional dispositions'. A truly successful educational environment then, according to Dewey, is one where the reaching out of an experience may



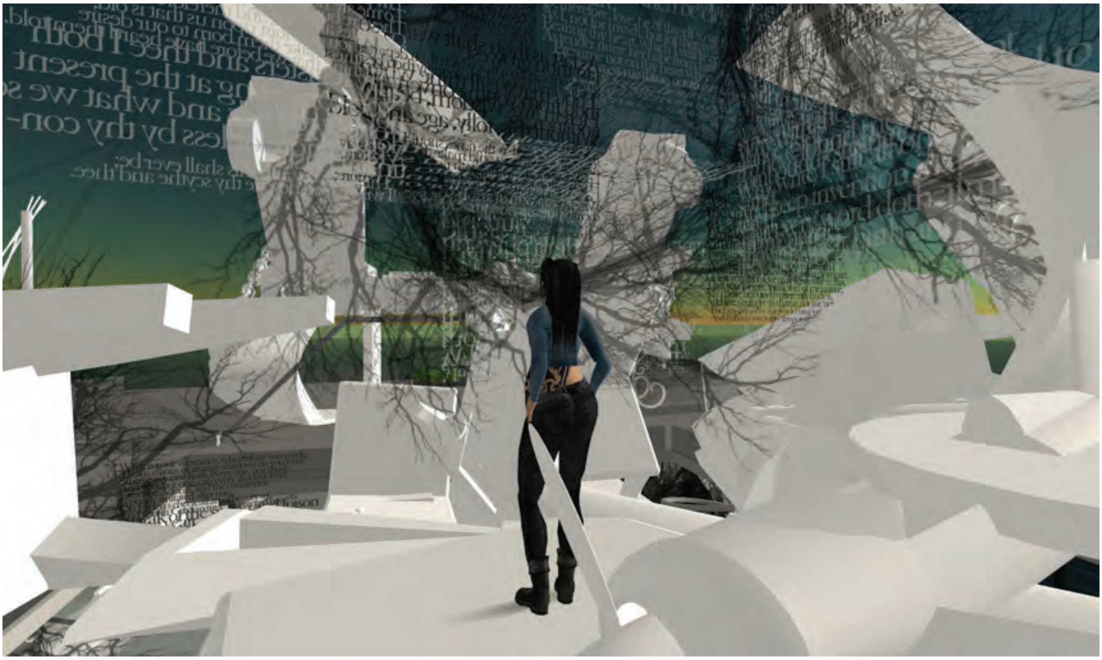


Figure 5: art installation/art installation-and-avatar (both) Exhibition of 2 installations by Mosmax Hax and Alpha Auer, curated by Scar Undset, Uninettuno Museum, Second Life.

be fruitfully rewarded and kept continuously active, as well as its outcome closely monitored.

For ground<c>, which is at its core a design project, Dewey's proclamations on the importance of environmental design in education are crucial. While the Groundcourse, with its behavioural restraints and irritants took into account the value of both experience and environmental stimuli, ground<c> will be able to put into practice Dewey's convictions to even further use by designing the entire architecture to suit the needs of experiential learning by taking full advantage of the affordances of the virtual. Real-world constrictions would not have enabled the design of spaces for the Groundcourse that were thoroughly changeable, interactive and indeed unpredictable in the 1960s: spaces where space itself could become a hindrance, an obstacle to be surmounted – in short an irritant. Space free of gravity, space with increased/decreased collision detection, space that shrinks and expands, space that is beyond the user's control can be used in a series of assignments to enhance perception, visual observation and in defining behavioural experiments to aid creative enablement in ground<c>. Indeed such space need not even be perceived identically by multiple learners: it is entirely conceivable to create space that presents itself with differences, ranging from the subtle to the drastic, to different users at the same time. A three-dimensional construct, incorporating highly interactive/ kinetic elements, that will provide an unpredictable, changeable learning environment that can be adapted to specific needs of instruction/ experience with great ease. Indeed these spaces will constitute the fulcrum of all learning activity and the entire campus will be structured around them. Complementing these will be static components for auditoriums, meeting areas, display and performance areas, etc. The overall manifestation will be a strongly interconnected set of structures, based upon forms of growth and visionary architecture, utilizing the sky, the earth as well as the ocean of the metaverse; creating a visionary/virtual campus for creative activity in that geography. In fact what has been described here can be summarized with one word alone: a holodeck (Murray 1998).

Conclusion

Given that the learning content of the creative fields is 'open ended' by its very nature and as such does not seem to readily lend itself to an implementation within the structure of present-day, two-dimensional virtual learning environments, can such an environment/methodology be developed in the open-ended three-dimensional structure of a metaverse, based upon the critical examination of a real-life, historic precedent?

While ground<c> is indeed strongly inspired by the Groundcourse, an exact replication is clearly not intended; nor indeed would such a replication be possible or meaningful, given the changes wrought about by technological, cultural, socio-economic and political change over the past 50 years. Thus, the principles of the Groundcourse that the author intends to fully adhere to, whilst developing ground<c>, are the irritants and role play in aid of the enablement of creative activity and the very large and diverse faculty for the formulation and instructional implementation of those very irritants and role play. But even here telematic connections, the metaverse and the possibilities engendered by virtual architecture will bring about considerable change and addition to the underlying concepts, as has indeed been delineated above.

Just as in the real world, very little is under the instructors' or the learners' control in a metaverse. Thus the metaverse will challenge and 'irritate' with its inherent conditions, socially, geographically, architecturally. From a dedicated campus, learners and instructors can then disperse to conduct in-world classes, assignments and experiments that further the experiential learning process. Avatars and all the appended social interaction can be used to great efficiency in acquiring and acting out new personalities, as well as their calibration and monitoring, fulfilling the concept at the very heart of Ascott's educational methodology.

Recent developments in educational theory, such as e-education, transformative learning and constructionism as well as the novel field of cyberpsychology will be incorporated into the instructional approach, culminating in a methodology which may then be considered as a novel approach to instruction for creative enablement, built upon the Groundcourse. A large and diverse faculty, actively engaged in an exchange of ideas and methodologies in the formulation of a diverse pool of exercises and appended irritants, as well as a student body, can today be established on a far more dramatic scale through the usage of the World Wide Web, overcoming geographical dispersion. The educational irritants and the element of confusion in the Groundcourse's teaching methodology, which are felt to carry as much potential educational impact today as at the time of their inception in the early 1960s, can be adapted and implemented through electronic interactivity, programming and the usage of temporal as well as structural electronic space, in a manner which was not available in the 1960s.

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Cedric Price's Generator and the Frazers' systems research[1]

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Abstract

From 1976 onwards, Cedric Price engaged in a project called Generator. *This paper focused on Cedric Price and John and Julia Frazer' work and their exchanges during the Generator project. The project ended up being acknowledged as the first Intelligent Building.*

Keywords

Cedric Price
John and Julia Frazer
Generator
Intelligent Architecture

Introductory Note

This paper is based mainly in material from the Cedric Price Archives held at the Canadian Centre for Architecture. The following abbreviations were used: GDF for Generator Document Folio; CPA-CCA for Cedric Price Archives – Canadian Centre for Architecture, Montreal; CPA for Cedric Price Architects; C.Price for Cedric Price; J.Frazer for John Frazer, H.Gilman for Howard Gilman. The paper is dedicated to Neil Spiller who supervised my PhD Dissertation and to Roy Ascott who examined it. I am grateful to Oporto's University "FAUP for their support for the realisation of the documents "Towards a Responsive Architecture: Cedric Price's Generator and Systems Research (FAUP, March 2006) and "Envisioning an Evolving Environment: The Encounters of Gordon Pask, Cedric Price and John Frazer" (FAUP, February 2007). A Fundação para a Ciência e Tecnologia's scholarship fund made this research possible (Co-financiamento do Programa Operacional da Ciência e Inovação 2010 e do Fundo Social Europeu).

The 3 images are from John and Julia Frazer's personal archive and reproduced with their permission

1. Introduction

Cedric Price's Generator project arose in 1976 in response to a commission by Howard Gilman – the co-chief executive of the American Gilman Paper Company – for its White Oak Plantation located on the Florida/Georgia border.[2] A synthesis of the Generator project figured in the 1984 publication *Cedric Price Works II*; visual material related to the project figures in MoMA's *The Changing of the Avant-garde* (2002), while its computational programmes are mentioned in Spiller's *Cyber Reader* (2002).[3] Generator's project material can be found today in the Cedric Price Archives held by the Canadian Centre for Architecture (CCA), where I conducted primary research in 2005. An analysis of this material shows that Price conceived of

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2. The brief for the project was outlined by Pierre Apraxine.

   Cedric Price to Howard Gilman, 'Minimal initial brief – as noted by PA, 7-11-76', 12 December 1976. Generator Document Folio, DR1995:0280:651 3/5. Cedric Price Archives – Canadian Centre for Architecture, Montreal. [Hereinafter GDF, DR1995:0280: 651 3/5, CPA-CCA]

3. See the following material:

   Ron Herron and alts (eds), *Cedric Price Works II*, London: Architectural Association, 1984, pp. 92–97.

   Terence Riley (ed.), *The Changing of the Avant-garde: Visionary Architectural Drawings from the Howard Gilman Collection*, New York: MoMA, 2002, pp. 92-97.

it as a 'generator' both for the site and the client's company, which could take the form of distinct architectural complexes in order to absorb diverse actities and shifting desires. In short, the proposal consisted of an orthogonal grid of foundation bases, tracks and linear drains, in which a mobile crane could place a kit of parts comprised of cubical module enclosures and infill components (i.e. timber frames to be filled with modular components raging from movable cladding wall panels to furniture, services and fittings), screening posts, decks and circulation components (i.e. walkways on the ground level and suspended at roof level) in multiple arrangements. The design focused on the detail and interrelationships of all the components, although it was always to be understood as a menu for facilitating change. At a later stage of the project, Price invited the Frazers to join the Generator's team effort (which included Frank Newby, Douglas Smith, Sandy Brown Associates, Leslie Zizman, Marvin Boutwell, LAW engineers, Robertson Ward, William Cannady, Wallace Prince and Barbara Jakobson) as systems consultants. This text focuses on their exchanges during the original project version, and the Frazers' computational research and systems contribution to the Generator project that envisioned enabling and stimulating the regeneration of the complex. Price's conception of Generator as a reconfigurable, modular complex made possible its absorption within the technological framework of computation and artificial intelligence and, through the application of the Frazers' research, the project ended up being acknowledged as the first intelligent building.

2. The Frazers' systems research

Generator was a masterpiece that broke through the architectural limits of its time. An analysis of the Generator project material held at the CCA expresses Price's design philosophy in favour of an impermanent architecture open to users' participation and his emphasis on broad experimentation in the design process. It also reveals the architect's exploration of consultancies that could further enrich his design, and his manifold interests, which included cybernetics, electronics and computers. While Price's acknowledgement of the importance of computation and systems research's potential leads back to earlier projects such as the Fun Palace,[4] the Generator project expresses Price's continuing pursuit of a responsive architecture. In this connection, the surfacing of interests in electronics and similar matters during the project development is noticeable. It included, in 1977, references to gadgets such as 'electronic umbrellas',[5] the use of 'citizen band radio'[6] and 'bleepers',[7] or the equation of the physical and electronic dialectic. A project press release, distributed on 13 December 1977, envisioned the existence of communicational 'links'[8]. Also noticeable is an early drawing, titled 'Site potential computer model' showing a plan of the project area near the river with several notes;[9] and that the suggestive item 'Personalized computer equipment' was annotated on a sheet dated mid-1977.[10] Around that same date, Bowdler from acoustic consultants Sandy Brown Associates mentioned that, 'Preliminary computer investigation have been carried out to ascertain the effect on internal acoustics by adding reflective panels[. . .]',[11] and the firm's September 1978 report envisaged an audio-visual system that included components such as computers, CCTV, and some other interesting sophisticated facilities such as 'echo facility',

Neil Spiller (ed.), *Cyber Reader: Critical Writing for the Digital Era*, London: Phaidon, 2002, pp.84-89.

4. I suggest reading:

   Stanley Mathews, 'The Fun Palace: Cedric Price's Experiment in Architecture and Technology', *Technoetic Arts*, 3: 2 (September 2005), pp.73-91.

5. C. Price, 'Random tasks', 20 September 1977. GDF, DR1995:0280: 651 3/5, CPA-CCA.

6. Mark Palmer (CPA), 'Information required IR 2[. . .]', 24 October 1977. GDF, DR1995:0280: 651 3/5, CPA-CCA.

7. Nic Bailey (CPA), 'Bleeper walker', undated. GDF, DR1995:0280:651 3/5, CPA-CCA.

8. Gilman Paper Company, 'For release[. . .]', 13 December 1977. GDF, DR1995:0280: 651 5/5, CPA-CCA.

9. C. Price, 'Site: Potential computer model' (sk29), undated. GDF, DR1995:0280:651 2/5,CPA-CCA.

10. C.Price, untitled notes (Notes 'to file', including 'Personalized Computer Equipment' etc.), 8 July 1977. GDF, DR1995:0280: 651 3/5, CPA-CCA.

11. Cedric Price Architects (CPA), 'Telephone message from Sandy Brown Associates[. . .]', 19 July 1978. GDF, DR1995:0280: 651 5/5, CPA-CCA.

‘sound-light interaction facility’, ‘[. . .] simulated acoustics of other buildings, self-operated audio and visual links with forest, river etc.’[12] I also noticed in the archive that there is a computational printed sheet dated August 1978 (eventually kept to be used or given as an example), which contains a code sequence and a reference to ‘Information Systems’, indications of an area of 70 x 70m^2, and an element of 3.6m length/width of 3.0m height.[13] As aforementioned, in addition to these early items, a strong engagement with computational technologies was developed at a later stage of the design. It is a fact that Price himself did not use computers but, as Finch alluded, Price ‘[. . .] anticipated, in Generator and InterAction Centre, much of the computer design developments of the following 25 years [. . .]’.[14] In the Generator project, computation and systems were to be used as critical tools in order to deal with its intrinsic complexity and to respond to the project’s initial predisposition of impermanency. And it was for this task that, in late 1978, Price invited John Frazer – a former professor of his collaborator, Nic Bailey – and his wife, Julia Frazer, to act as systems consultants.

From early on, John Frazer was one of those who had acknowledged and researched the impact of computation on the practice of architecture in design, on the architect–client relationship, and on the spatial environment. This led back to a phase of what he described as ‘Computing Without Computers’.[15] Frazer trained as an architect in London and Cambridge during the 1960s and 1970s and, as a student, he already applied computer technology and printed his work of 1968 (his fourth year) on a plotting machine while being filmed by the BBC.[16] Frazer had then developed a project titled ‘Reptile system’ that was published in *Arena*, and provisionally patented in 1968.[17] (Out of curiosity, Frazer’s fifth-year Architectural Association (AA) thesis was called ‘Autotectonics’).[18] According to Frazer, the systems ‘[. . .] produce enclosures of a very wide variety of plan shapes and complex structural forms’.[19] More importantly, in 1971, a simple program applying the computational method called the ‘seeding technique’ was developed for the ‘Reptile system’. The Reptile system was published in *Architectural Design* as well in 1974,[20] and from early on, it was acknowledged that the seeding technique facilitated broader applications, enabling it to be applied later in a more general-purpose program. Between 1969 and 1973 John Frazer was a lecturer at Cambridge, where he had access to mainframes; and then, from 1973 to 1977, he taught at the AA. [21] In 1977, he was appointed professor in the Faculty of Arts and Design at Ulster Polytechnic – a school that bought three powerful Tektronix computers – where he would continue to develop his research on computer-aided design.[22] In 1979, John and Julia Frazer founded their own business platform: ‘Autographics’. The company, throughout its life, achieved many awards and was a pioneer in the area of software, design systems for microcomputers and design education. It was precisely during this time that the Frazers refined a computational technique inspired by the cellular automata, and between late 1978 and 1979 they introduced the term ‘Intelligent Modelling’. (One noticed that the archive contains a sheet, dated mid-June 1978, prepared by John Frazer on the topic.)[23] Later on, the Frazers developed three-dimensional and general-purpose versions of the system.

The Frazers’ computational and systems research and consultancy made a major contribution in relation to the performance of Generator.

12. Dick Bowdler, ‘Generator Acoustics Report N.2’, 29 September 1978. GDF, DR1995:0280: 651 5/5, CPA-CCA.

13. Unknown author, untitled (Print sequence of computational code), received at CPA on 7 August 1978. GDF, DR1995:0280: 651 1/5, CPA-CCA.

14. Paul Finch, ‘Cedric Price: The Person in Whose Company Time Passed Quickest’, in Samantha Hardingham (ed.), *Cedric Price Opera*, London: Wiley, 2003, pp. 122–23.

15. John Frazer [Hereinafter J. Frazer], ‘Computing Without Computers’, in Samantha Hardingham (ed.), *Architectural Design* – ‘The 1970s is Here and Now’, 75: 2 (2005), pp. 34–43.

16. J. Frazer, Interview with the author, 22 March 2005.

17. See the following material:

    J.Frazer, ‘Reptile System’, in: *Arena*, 84: 9123 (1968).

    J. Frazer, ‘Reptile System’ (Provisional patent 31256), July 1968.

18. J. Frazer, interview with the author, 15 April 2005.

19. J. Frazer and J.M. Connor, ‘A Conceptual Seeding Technique for Architectural Design’ (Paper for *PArc 79* conference), ca.1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.

20. J. Frazer, ‘Reptile System’, *Architectural*

Design, 49: 4 (1974), pp. 231–41.

21. See endnote 18.

22. See endnote 16.

23. J. Frazer, 'Intelligent Modelling Systems', 16 June 1978. GDF, DR1995:0280: 651 5/5, CPA-CCA.

24. C. Price, 'Immediate work Programme resulting from London Meeting – December 1978', 8 December 1978. GDF, DR1995:0280: 651 3/5, CPA-CCA.

25. There is correspondence in the archive from 20 December 1978 until the end of the original project version and beyond. CPA, 'Dwg issued' (Chart of material issued to the Frazers), 1978–79. GDF, DR1995:0280: 651 5/5, CPA-CCA.

26. See endnote 16.

27. J. Frazer description follows: '[. . .] then I suggested to Cedric that the thing should get bored with this arrangement. And then the idea was that, if it got bored, it would move. [. . .] the reason to all this is to try to provoke learning. [. . .] However the idea of boredom was actually Gordon's idea. If we go back now to [. . .] his first machine – the Musiccolour machine – has memories in it for each rhythm. And if it didn't keep changing that, it got bored. The program would turn all its lights out. So I made this connection [. . .]'

    See endnote 16.

28. Among the material issued there were some old drawings

References to computer programmes were already annotated in handwritten text by Price within the 'maintenance' item from a copy of the document 'Immediate Work Programme [. . .] December 1978'.[24] The development of a short but prolific exchange between the fields of architecture, computational and systems research was initiated. This would result in a sequence of detailed proposals, computer-generated visual material and computer-controlled, interactive, electronic model prototypes that simulated, through different levels of sophistication, the idea of a responsive, intelligent building constituted by a kit of parts into which were embedded a series of electronic components linked to a microprocessor running a series of software. [25] Frazer summarized:

> In 1978 I got a phone call [. . .] from Nic Bailey [. . .]. In 1979, we actually did the computer program for it on this Tektronix [. . .] it was the first thing in microprocessor [. . .]. However [. . .] the Commodore Pet [. . .] had 4K of memory [. . .]. I said to Cedric: 'Look, we can make the building literally intelligent and what we need to do is imbed one of these microprocessors in each part of the building itself'. [. . .] And then we made this working model [. . .][26]

(Frazer also made reference to the idea of a 'building that could learn from the interaction with the user'. [27])

3. Computational proposals and programs

The initial contact with the Frazers concerning Generator occurred around 20 December 1978, when Price sent a letter stating: 'I enclose a preliminary set of information to give you some idea of the project.'[28] It included a memo, drawings and sheets about activities' questionnaires. The set provided an explanation of the project and described its intentions and components (i.e. cube structures, in-fills, screens, circulations and drains), as well as its requirements (for instance, geometric parameters related to the enclosures, screens and crane routes). Price concluded his letter with a clear description of the project and restated the aim of a responsive architecture: 'The whole intention of the project is to create an architecture sufficiently responsive to the making of a change of mind constructively pleasurable. Yours sincerely, Cedric Price'[29] Two weeks later, Cedric Price Architects prepared 'Notes for JF' and enclosed one more drawing.[30] Some technical requirements that limited the catwalks, cube units and screen positioning (including the electrical cables' span), were emphasized. In fact, it seems that one of the initial reasons why computers were required was to assist in handling the overlapping parameters involved in the Generator's performance in order to assure, just as the architect had expressed in 1977 to his quantity surveyor, that the regeneration should be a process of delight for the visitor.[31] Additionally, as aforementioned, the project aimed to promote continual change through a responsive architectural absorption of one's 'change of mind'.[32]

In early January 1979, the Frazers sent a paper that had just been prepared for a conference in Berlin, and advised that 'proposals [were] to follow in the next post'.[33] Days later, exhaustive proposals for the project were delivered. The project appeared to be classifiable as an 'automatic/generative' case centred on a 'user–machine' relationship; and Frazer outlined the sequence of proposals (mentioning 'second thoughts but using the same system as before') relating his expertise to Price's design necessities and highlighting the benefits provided at different levels.[34] The first proposal, associated with a level of 'interactive' relationship between 'architect/machine', would assist in drawing and with the production of additional information, somewhat implicit in the other parallel developments/proposals. The second proposal, related to the level of 'interactive/semi-automatic' relationship of 'client–user/machine', was 'a perpetual architect for carrying out instructions from the Polorizer' and for providing, for instance, operative drawings to the crane operator/driver; and the third proposal consisted of a '[. . .] scheduling and inventory package for the Factor [. . .] it could act as a perpetual functional critic or commentator.'[35] The fourth proposal, relating to the third level of relationship, enabled the permanent actions of the users, while the fifth proposal consisted of a 'morphogenetic program which takes suggested activities and arranges the elements on the site to meet the requirements in accordance with a set of rules.'[36] Finally, the last proposal was

> [. . .] an extension [. . .] to generate unsolicited plans, improvements and modifications in response to users' comments, records of activities, or even by building in a boredom concept so that the site starts to make proposals about rearrangements of itself if no changes are made. The program could be heuristic and improve its own strategies for site organization on the basis of experience and feedback of user response.[37]

This was particularly audacious, for it advanced the idea of an architectural complex with its own 'life and intelligence' that would be both interactive/responsive and creatively evolutionary. It alluded largely to a cellular automata conceptual frame of reference and the ideas of self-replication. Frazer declared: 'Within the usual definition of life as being a self-replicating information system, then the elements on the site should constitute a self-replicating information system and be provided with an appropriate intelligence.'[38] He also wrote some (almost illegible) notes, that include: 'If you stop people in the street and ask then to define life they usually retort "[. . .] self replicating information system [. . .]'."[39] (All this must have captured Price's attention; he annotated: 'Inventory of where things are and what they are at any particular time.'[40])

Frazer expressed interest in all the above proposals, but noted that level 3 was less straightforward than the others. He pointed to the necessity for Generator to gain an 'adequate intelligence'. In relation to this, Frazer made the following note: 'Although they are where I do most of my thinking.'[41] Frazer also explained the process of program writing, by distinguishing a final program from its demonstration version, obtained at lower costs and with less time expenditure. He suggested making a feasibility study through a demonstration program including work on all of the proposals, since it '[. . .] would be more efficient as there is [a] lot of overlap.'[42] Frazer also wrote another explicit note (at the bottom of the last page):

> You seemed to imply that we were only useful if we produced results that you did not expect [. . .] I think this leads to some definition of computer aids in

(e.g. sk130, 132-019 and 092). C. Price to J. Frazer, 20 December 1978. GDF, DR1995:0280: 651 5/5, CPA-CCA.

29. See endnote 28.
30. N. Bailey to J. Frazer and Julia Frazer (Letter mentioning 'Generator-Notes for J.F.'), 8 January 1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
31. C. Price to Douglas Smith, 28 July 1977. GDF, DR1995:0280: 651 5/5, CPA-CCA.
32. See endnote 28.
33. Julia Frazer and J. Frazer to C. Price, 8 January 1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
34. The proposals were annotated by Frazer and by Price.

    J. Frazer to C. Price, (Letter mentioning 'Second thoughts but using the same classification system as before'), 11 January 1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
35. See endnote 34.
36. See endnote 34.
37. See endnote 34.
38. See endnote 34.
39. See endnote 34.
40. See endnote 34.
41. See endnote 34.
42. See endnote 34.

> general. I am thinking about this but in the meantime at least one thing you would expect from any half decent program is that it should produce at least one plan which you did not expect.[43]

In a certain way, the idea of a computational aid in the Generator project also acknowledged and intended to promote some degree of unpredictability.

During this time, the Frazers drew perspectives using a model of the grid. The material produced corresponded to a demonstration stage that could be more fully developed later on to a higher level of sophistication, robustness and detail. Most of the process consisted of Frazer's work effort, like programme conceptualization etc, complemented by some computer time at Tektronix, which involved an additional consultancy fee to be paid to the Innovation and Resource Centre of Ulster Polytechnic where Frazer taught.[44] Price's office acknowledged the two letters from the Frazers, and replied: 'He will be in touch.'[45] During the same month, he already mentioned in the press Frazer's proposal and his design capacity to benefit from its potential.[46]

Weeks later, on 2 March 1979, Price mentioned to the client the delivery of material related to three of the six computational programs. He made reference to, 'Three of six proposed computer programmes that would help the running of Generator siding to the Factor and the Polorizer. The other 3 programmes are all graphic ones which just help me!'[47] (It is to be noted that, the project material in the archive indicates that the period between late 1978 and early 1979 corresponded to an intense work phase in the project, even though the client proceeded to mention a temporary suspension in October 1979.[48]) The computational material constituted an attractive information source and support in giving great credibility to the project's viability, maintenance and performance. In this connection, initial demonstration material (perspectives made with the first grid model etc.) to which the Frazers made reference in their proposals, was almost certainly shown to the client. The endeavour was also registered in the press. In late February 1979, an article in *Building Design* included a computer perspective by Frazer: 'These are the first illustrations to be published of Cedric Price's mysterious scheme "Generator" [. . .] The site in Florida has been cleared and a prototype unit installed.'[49] In an *Architectural Review* article, in preparation since October 1979 and launched in January 1980, presenting a synoptic overview of the project, John Frazer figures in the systems consultancy credits.[50] In presentation and similar material mounted on A4 cardboards by Cedric Price Architects, pertaining to a later date, at least from July 1979, the Frazers' electronic model is evident, composed on a board with the cube models, microprocessor, screen display and printer.[51] As shall be described, other articles were published during the following months, and the project was even mentioned abroad. As later highlighted in a 2003 French article, the project had a seminal role in advancing architecture towards artificial intelligence.[52]

4. The Frazers' research and techniques

The 1970s were important for the development of the Frazers' computational research and technical developments. In the late 1970s, John Frazer continued to conduct research on the 'seeding technique' and, between 1978 and 1980, the Frazers refined the 'intelligent modelling' system, which had one of its first applications in the Generator project. Frazer's awareness

43. See endnote 34.
44. See endnote 34.
45. Anna Ericson (CPA) to J. Frazer and Julia Frazer, 16 January 1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
46. See: J. Frazer, 'The Continuing Relevance of Generator', in Samantha Hardingham (ed.), *Cedric Price Opera*, London: Wiley, 2003, pp. 46–48.
47. C. Price to H. Gilman, 2 March 1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
48. H. Gilman to C. Price, 29 October 1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
49. W.A., 'Cedric Price's Generator', *Building Design*, 434, 23 February 1979, p. 9.
50. CPA, 'Cedric Price Generator, Florida, USA', *Architectural Review*, London, January 1980, pp. 16–17.
51. CPA, untitled (copy of photograph of an electronic model), undated. GDF, DR1995:0280: 651 4/5, CPA-CCA.
52. Dominique Rouillard, 'Cedric Price: Disaparition d'un Architecte qui Voulant Mettre la Technique au Service des Delicies et Uncertitudes de la Vie', *A. M.C.*, 137 (October 2003), pp. 31–32.

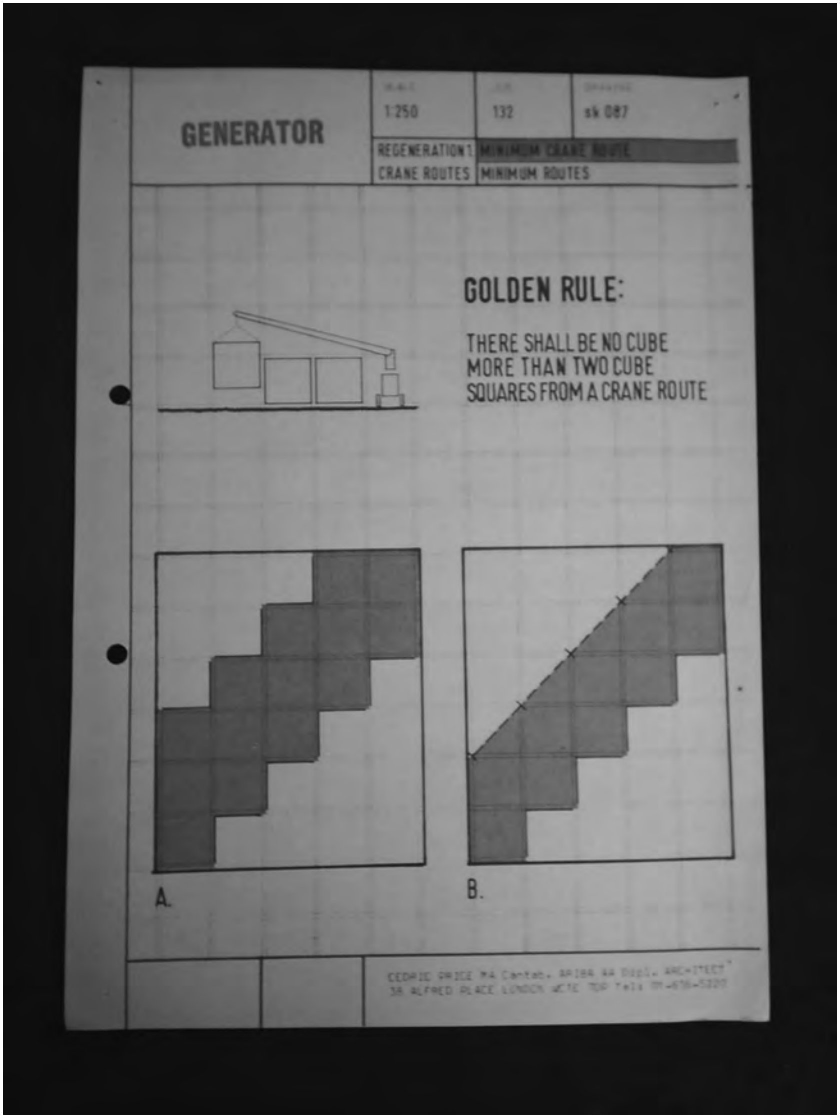

Figure 1: Cedric Price Architects, Generator Project Drawing SK 087 (provided to the Frazers), ca. 1976–1979. Untitled Document Folio: John and Julia Frazer Personal Archive.

of the profound impact that microprocessors and CAD had on the practice of architecture was explicit in an early paper abstract that he enclosed in his very first letter to Price. (I pause to point out that I noticed that Price marked the aforementioned abstract with the note 'The silly bits'; it thus is likely that it was enclosed in Frazer's letter to Price on 8 January 1979, since that letter (which also enclosed the Berlin paper) refers to the attachment of 'some silly extracts [. . .] which were removed from the final paper'.)[53] Frazer, who had recently been appointed professor in Ulster, stated:

> To maintain now that the computer is just a tool for the architect like a slide rule or a t-square is quite absurd. [. . .] There are still architects who believe

53. See endnote 33.

> that computers will not fundamentally change their role and there are even those in the CAD business who are encouraging them in this complacent fantasy. Architects are free to believe whatever they wish but as an educator, I have a moral responsibility to educate people to have a useful role in the future.[54]

Such an abstract was related to a paper titled 'A Conceptual Seeding Technique for Architectural Design' that ended up being co-authored and presented by J. Frazer and J.M. Connor (Julia Frazer) at the 1979 International Conference on the Application of Computers in Architecture, Building Design and Urban Planning.[55] The authors criticized the conventional approach to CAD methodologies, which pretended to reflect the traditional ones, and expressed a willingness to avoid hierarchical approaches and the mere 'primitive manual design methods' still common in the use of computers. Price underlined sections of the Frazers' paper, curiously annotated 'as Pask', in which the author emphasized the urgency for the development of new CAD methodologies that enabled complex concepts used in design to be dealt with.[56] The Frazers continued by describing an alternative – the seeding technique – which had been used earlier in 1970 for the Reptile system design and that was now being developed for a general purpose through the Autotecton program in which computing and data packaging limitation are 'no longer a problem'. This approach 'enables the designer to crystallize a generalized design concept which embraces formal, structural, constructional, aesthetic and other considerations. The program then allows this concept to be manipulated into specific building forms in response to a particular problem.'[57] Price certainly identified his own architectural approach to this, since his annotation shows an intention to 'quote John Frazer'. Frazer stated:

> It may well be that in any one generation there are few designers who can think with the necessary conceptual clarity to invent interesting seeds which can produce rich building forms. We are at present suffering the environmental consequences of the period in which every architect was trained to consider himself a genius. A reduction in the number of potential designers might be seen as a positive advantage by most people outside the architectural profession.[58]

Frazer also developed the architectural application of the Intelligent Modelling system – a term he introduced in an entry for the NCC/NRCD Sponsored Microprocessor Competition in 1979. A working model was made; and it is possible that the very first visual material for Generator, such as the perspective that appears in *Building Design* in February 1979, was produced with a similar system. One notes again that evidence exists that Price was provided with Frazer's A4 text titled 'Intelligent Modelling Systems' dated 16 June 1978.[59] In parallel to this, acknowledgement should also be made of the importance of Robert Aish's article '3D Input for CAAD Systems', published in the second volume of *Computer Aided Design* in March 1979. Apart from this, Paul Coates also developed work on cellular automata at Liverpool Polytechnic School of Architecture. (In fact, Frazer's polytechnic and Coates's polytechnic would also develop a joint research

54. J. Frazer, 'Summary of proposed paper – A Conceptual Seeding Technique for Architectural Design', ca.1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
55. The paper was annotated by Price.

    J. Frazer and J.M. Connor, 'A Conceptual Seeding Technique for Architectural Design' (paper for *PArc 79* conference), ca.1979. GDF, DR1995:0280: 651 5/5, CPA-CCA.
56. See endnote 55.
57. See endnote 55.
58. See endnote 55.
59. See endnote 23.

project and co-authored some papers.) According to the definition provided in one of Frazer's 1980 texts, the technique of

> [i]ntelligent physical three-dimensional modelling systems implies physically incorporating local intelligence or logic circuits into the kits of parts for building a physical model; the model can be viewed by a human observer as a physical representation and simultaneously understood as a logical electronic model. The computer is able to interrogate the physical model and deduce its organizational configuration. The data derived from this interrogation can be used to provide immediate feedback during the construction of the model or the data can be stored for later use. Feedback might take the form of additional projections of the model under construction (such as displaying internal plans) or might be instructions about the rules of further extending the model (such as building regulations or structural constraints).[60]

This text excerpt pertained to a draft paper prepared in co-authorship by John, Julia and Peter Frazer for the Computer Graphics 1980 Conference. The paper is dated 12 March 1980 and a copy was received by Cedric Price Architects on 18 March, a year after the Frazers' computational proposals for Generator. This paper, which briefly referenced the cellular automata concept, Aish's article, and Coates's work, described 'Intelligent Physical Three-dimensional Modelling Systems' that did not require a grid baseboard. As Frazer said:

> The potential advantages of a simple form of intelligent modelling related to architectural applications on a gridded baseboard are established elsewhere (Aish, 1979). [. . .] [T]he authors of this paper describe a technique employing a non-linear data bus. The non-linear data bus frees the model from the constraints of a gridded baseboard and permits complex three-dimensional non-orthogonal forms.[61]

The paper concludes 'by describing a proposal to employ the intelligent modelling technique in a full scale flexible building system.'[62] That building was Cedric Price's Generator. According to another of Frazer's papers, intelligent three-dimensional physical system was first demonstrated in working form at that same 1980 conference.[63]

5. Generator computer programs, models and perspectives

On 18 March 1980, Jo Binns, from Cedric Price Architects, prepared a rental order for equipment.[64] (I highlight that this happened after the client's notice, dated October 1979, of the project's temporary suspension.)[65] Binns's order draft is likely to have been related to her parallel research notes on 'Instructions for computer programme in case of hiccups.'[66] On the latter, Price annotated 'Commodore Pet 8k', i.e. precisely the model referred to in Frazer's initial third proposal. [67] The PET (Personal Electronic Transactor) was one of the first microcomputers – it was the first full-featured Commodore personal computer, and it was only produced after 1977.[68] Since not everyone could afford one, it was frequently rented from a shop in order to run programs, made by an expert, with which users often faced hiccups or bugs. In this connection, it must be highlighted that, as mentioned,

60. J. Frazer, Julia Frazer and Peter Frazer, 'Intelligent Physical Three-dimensional Modelling Systems' (paper for *Computer Graphics 1980* conference), 12 March 1980. GDF, DR1995:0280: 651 4/5, CPA-CCA.
61. See endnote 60.
62. See endnote 60.
63. J. Frazer, Julia Frazer and Peter Frazer, 'New Developments in Intelligent Modelling' (paper for *Computer Graphics 81* conference), ca.1981. GDF, DR1995:0280: 651 4/5, CPA-CCA.
64. Jo Binns (CPA), untitled letter, 18 March 1980. GDF, DR1995:0280: 651 3/5, CPA-CCA.
65. See endnote 48.
66. J.Binns, 'Instructions for computer programme. In case of hiccups', 18 March 1980. GDF, DR1995:0280: 651 3/5, CPA-CCA.
67. See endnote 66.
68. One recalls that the PET 2001 had 4 or 8 K of 8 bit RAM.

Frazer acknowledged the impact of microprocessors in architecture and, to some extent, the Generator's development itself was permitted by the advent of micro-computation in the mid-1970s.

A week later, on 25 March 1980, the 'Generator Florida US – Computer Programmes' were outlined in a sheet from Cedric Price Architects. It transcribed an excerpt of the aforementioned paper by the Frazers on 'Intelligent Physical Three-Dimensional Modelling Systems' (i.e. the paper's pages 10 and 11 focused on 'Example 5 – Generator'), with only a few amendments and a new introductory sentence by Price stating that 'Microelectronics help produce the first intelligent building'.[69] This sentence links the emergence of the first intelligent building (IB) with the rise of microelectronics. A note was also added at the end, consisting of a transcription from Frazer's caption for an illustration, received on 27 March, summarizing the technical process:

> As parts are added to the three-dimensional model the microprocessor control unit interrogates the structure to discover the present state of its configuration. A television monitor screen displays statistical data, analysis or just shows projections of the current state of the model. The tape recorder stores the image of the model for future use for further calculations and the production of working drawings.[70]

These few sentences describe the computational process that Frazer denominated as an intelligent modelling system, as well as the group of hardware components applied consisting of the model with plug-in electronic pieces, the microprocessor and data storage, the TV screen and printer output display. At the bottom of the page, there are credits indicating that the Frazers' consultancy also benefited from the help of Depak Kaushal from Ulster Polytechnic, in the construction of the model, and of Frazer's relative, Peter Frazer of Cestavon Ltd, with the electronics.[71]

There are several copies of the two-page excerpt of Frazer's paper, which Price used and onto which he made handwritten annotations and small amendments for deciding what should be typed in the 'Generator Florida US – Computer Programmes'.[72] The opening sentence of one of the copies stated, according to Price's amendments, 'The consultants for the Generator scheme designed by Cedric Price for Gillman Paper Company', and excluded the original sentence which stated that: 'The final example shows that Intelligent modelling systems can be extended to possible activities in the real world where dwelling or configuration of objects are likely to change.'[73] At the end of the text, Price maintained Frazer's sentence '[. . .] in a sense the building can be described as being literally intelligent', and added (but later crossed out): 'It has been suggested that Generator is the first Intelligent Building.'[74] This expresses his awareness of the innovative ground that was being broken and the implications of the experimentations in applying Frazer's research achievements to the Generator.

The sheet 'Generator Florida US – Computer Programmes' describes the Generator's architectural constitution and function as a kit of parts, and goes on to specify Frazer's computational technique. The computer would develop a relationship with a series of movable chips included in the components of the building site. It applied a CAD database system and

69. CPA, 'Generator Florida US – Computer programmes' (Retyped information provided by the Frazers), 25 March 1980. GDF, DR1995:0280: 651 3/5, CPA-CCA.

70. See endnote 69.

One notes that the aforementioned illustration is titled 'Diagram view of intelligent modelling system', and on it Price wrote 'reference to photographs – to be added as a note to the Pink Memo').

See J. Frazer, 'Diagram view of intelligent modelling system' (illustration, attached to Frazer's letter to Price dated 20 March 1980), ca.1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

71. See endnote 69.

72. There are several copies; one of them was marked by Price with notes such as 'See Frazer letter 20-03-80'.

See, for instance: J. Frazer, Julia Frazer and Peter Frazer, 'Intelligent Physical Three-dimensional Systems', (excerpt marked with Price's annotations and amendments), 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

73. See endnote 72.

74. See endnote 72.

four computational programs (related to what was mentioned in the Frazers' six initial proposals – i.e. the architectural rules base, the inventory and site feedback aspect, the users' intervention-interactivity, and the architectural reconfiguration rearrangement process enriched by the boredom parameter). The text ends by returning to Frazer's allusion to a sort of living complex and the audacious opinion that, apart from the architect's intention to instigate continual and dynamic reorganization of the site, 'it was felt that Generator should not be dependent entirely on the users for investigating the organization of the site but should have a mind of its own.'[75] Contrary to passive CAD or a mere assistant to site organization, it was conceived of as active, adaptative and encouraging change – '[. . .] in a sense the building can be described as being literally intelligent'.[76]

A further letter from John Frazer, dated 20 March, provided information about Ulster Polytechnic's credentials, and its final sheet included the aforementioned illustration of the 'Diagram view of intelligent modelling system'[77] The letter mentions that Price returned a tape to Frazer (i.e. the computer data-recording method in use at the time). It is possible that the tape contained software that could be used by the Frazers or Price in the PET computer, mentioned in Binns's rental memo from a few days before, to create a presentation. Furthermore, the Frazers also attached slides of their improved version of a tree scanner model that did not require a baseboard, and said that 'better perspectives suitable for publication' were being sent.[78] Price's office manager acknowledged its receipt by stating that 'Cedric is looking forward to receiving the perspectives, and he will be writing to you when he has more news on publicity', thus expressing his interest in continuing to promote the project's research.[79] Some days later, Price himself also took some photographs.[80]

The information on Ulster Polytechnic was transcribed onto another Cedric Price Architects' sheet.[81] It presented the school and made a reference to computer-aided design techniques and to their Innovation and Resource Centre conceived of to engage the school's research with the outside. It also mentioned that a 'joint research project with Paul Coates [. . .] concerned with the teaching of design theory and, in particular, with problem identification and design strategy'[82] The description also clarified the intention to employ computers in order to enable the student to think and 'to solve his own design problems without taking away his initiative'.[83] One notes that at the time, computers were being seen as a way to improve various architectural fields, from the design process to the building itself and, in particular, to aid decision-making or to strategically assure experimentation in complex operations. In this connection, and as a matter of interest, one also notes that in the archive there is an interesting undated sheet tree diagram titled 'Explore some ideas about housing' (perhaps kept by Price for use as a reference) which reveals great ambition by equating items ranging from 'changes of the family' through 'change of mind' to 'politics'.[84]

In mid-April, Price's office manager acknowledged receiving the 'latest perspectives' from the Frazers, requested by Price in mid-March.[85] These probably referred to material necessary for publication since an article was to be published in *Building Design* in April 1980 and another one in the *RIBA Journal* June 1980 edition. An A4 sheet, onto which were annotated 'photograph titles', was possibly related to that.[86] As previously mentioned,

75. See endnote 69.

76. See endnote 69.

77. J. Frazer to C. Price, 20 March 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

78. See endnote 77.

79. J. Binns to J. Frazer, 27 March 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

80. C. Price to J. Frazer, 3 April 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

81. CPA, 'Ulster Polytechnic[. . .]', 9 April 1980. GDF, DR1995:0280: 651 3/5, CPA-CCA.

82. See endnote 81.

83. See endnote 81.

84. Unidentified author,' Explore some ideas about housing', undated. GDF, DR1995:0280: 651 5/5, CPA-CCA.

85. J. Binns to J. Frazer and Julia Frazer, 17 April 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

86. Possibly J. Frazer, untitled (marked 'Photograph titles'), undated. GDF, DR1995:0280: 651 5/5, CPA-CCA.

a computer perspective produced by Frazer had already appeared in the February 1979 *Building Design* article. However, it should be highlighted that already by early 1980 the Frazers had developed the idea of a three-dimensional model version unconstrained. The Cedric Price Archives at the CCA contains many wire-line aerial perspectives among the Generator project material. They were simple visual representations, likely to have been output from the Frazers' models by the computational demonstration version programs developed for Generator. I noticed that the archive also contains some perspective drawings that were curiously printed on sheets of paper with a stamp from the Liverpool Polytechnic.[87] There are also other wire-line perspectives drawn by Cedric Price Architects, likely to have been based on computational perspectives;[88] and, in fact, the office also used them as a basis for other figurative and detailed pictures and collages.

6. Generator's acknowledgement as the first intelligent building and other occurrences

In the first part of 1980, besides the important panoramic January *Architectural Review* article, other pieces were also published on Generator. In April 1980, *Building Design* published 'Thinking for Fun', a short but significant article since it emphasized the impact that computation had on the project, making it intelligent. It emphasized: 'One of the world's first architectural projects to have a mind of its own is being developed by Cedric Price. Price has revolutionized his long-standing Generator project in Florida with a pioneering computer program which makes the scheme "intelligent".'[89] The article refers to Generator as being under construction and describes the computational technique developed by the Frazers, acknowledging the innovative insight of the boredom concept. According to the article, Price declared what was stated in the Frazers' proposals: 'It was felt that the Generator should not be dependent entirely on the reorganization of the site but should have a mind of its own.'[90] Further on, it also alluded to the possible coexistence of humans and computers in the intelligent architectural complex by quoting Price:

> We are trying to install an amiable intelligence. As the technology stands we can [. . .] [t]he generator would be 'lively quietly' [. . .] But he denied that users would give up producing their own ideas. Users will not find that parts of generator [are] whisked away from under them. The actual changing of site components will be carried out by a human being, following instructions from the site itself.[91]

The project even received coverage abroad. A short article was published in a magazine called *Aftenpoften* in April 1980 and some articles were published in France.[92] The December 1980 article in *Architecture d'Aujourd Hui*, explicitly titled 'Au-delà du High-Teck', is significant for its concern with that parallel debate, making reference to 'Le Premier Bâtiment Intelligent'.[93] Price points to an ongoing abusive use of the term 'high-tech' and he continues by alluding to the privilege of research and a use of technology that more than its mere visual attributes attend to the complexity (of the human user). He states that: 'This "invisible conception" goes for instance in parallel with the development of microelectronics'; he identifies the common

87. Possibly J. Frazer, untitled (Perspective of cubes with stamp 'Liverpool Polytechnic Department of Architecture'), undated. GDF, DR1995:0280: 651 5/5, CPA-CCA.
88. See the undated CPA drawings titled 'perspective I to VIII' and numbered 132-068 to 075. GDF, DR1995:0280: 651 5/5, CPA-CCA.
89. W.A, 'Thinking for Fun', *Building Design*, 18 April 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.
90. See endnote 89.
91. See endnote 89.
92. Unidentified author, 'Blir Bevegelige hus det Tneste?', *Aftenpoften*, 22 April 1981. GDF, DR1995:0280:651 1/5, CPA-CCA.
93. C. Price, 'Au delá du High-Tech', *Architecture d'Aujourd Hui*, 212 (December 1980), pp. 15–16.

high-tech as 'extremely plastic'; and concludes by referring to Generator's use of less tangible technologies.[94] Another French article, published with the title 'Bâtiment: Immeuble sur Mesure', highlighted the revolutionary effect of a 'géometrie variable'. It notes that the Generator could be modified as one wishes, since 'the programmer calculates a new arrangement that transmits the plan to a crane conductor, and the crane itself is programmed to take action'.[95]

In the United Kingdom, where Price was based, the title of the June 1980 *RIBA Journal* had already pointed to the idea of the 'World's First Intelligent Building', mentioning Price's pursuit of responsiveness, the precedent of Fun Palace and the potential of microprocessors:

> The plummeting cost of microprocessors has enabled Cedric Price to design 'the world's first intelligent building'. 2,600 small logic circuits will be incorporated into Price's Generator [. . .]. Price has been a long-term exponent of interactive buildings and his building takes ideas first promulgated in Joan Littlewood's Fun Palace nearly 20 years ago to their logical conclusion to the extent that the building itself grows bored if people do not use it frequently enough. [. . .] The computer program is not merely a passive computer-aided design program nor is it just being used to assist with the organization of the site, but is being used actively to encourage continual change and adaptation to changing requirements.[96]

This piece paralleled another article in January 1981, authored by Deyan Sudjic titled 'Birth of the Intelligent Building'.[97] Sudjic described and pointed out the seriousness and originality of the endeavour of leading with electronics, enabling real responses to users' appropriation and even alluded that the building would become fully automatic when coupled with robotics:

> The technical brilliance that has gone into designing chips has not, it seems, been matched by anything more than boundless banality when it comes to serious applications. Not so far. But now Cedric Price [. . .] has been commissioned to build a retreat [. . .] that really uses electronics to the full. [. . .] [A]ssisted by Ulster Polytechnic computer consultants John and Julia Frazer, Price has developed a collection of programmes that will enable it to interpret the suggestions of users for changes to the system, display their consequences, and come up with its own suggestions for utilizing the 'potential' of the components. [. . .] Once coupled to the travelling robots that bedeck today's production lines, it could become fully automatic.[98]

Sudjic also pointed out the significance of the project concerning Price's long pursuit of responsiveness. In the following year, the *New Society* March issue carried an article highlighting the shifting shape of the project, (in a similar way to the aforementioned French column mentioning a 'géometrie variable'), and also refers to the current state of Generator: 'What may well be the world's first intelligent building is taking uncertain shape in Florida. [. . .] [B]y means of a few instructions from a central computer the building can change its shape and layout to meet the needs of people inside it. Following volumes of feasibility studies, the Generator's builders are watching it rise [. . .]'[99]

94. See endnote 93.

95. Unidentified author, 'Bâtiment: Immeuble sur Mesure' (photocopy), unidentified date. GDF, DR1995:0280: 651 5/5, CPA-CCA.

96. W.A., 'World's First Intelligent Building', *RIBA Journal*, June 1980, p. 63.

97. Deyan Sudjic, 'Birth of the Intelligent Building', *Design*, London, January 1981, p. 56.

98. See endnote 97.

99. W.A., 'A Building that Moves in the Night', *New Scientist*, 89: 1245 (19 March 1981), p. 743.

100. It is attested by letters from academics and the industry; and apart from references in the press in the early 1980s, Generator also figured in the 'Schemes exhibition'. See the following material:

Waddington Galleries, 'Schemes' (flyer), 1981.

Maurice Amiel (Université du Québec) to C. Price, 16 February 1981 GDF, DR1995:0280: 651 5/5, CPA-CCA.

Michael Carson (PSP Ltd.) to C. Price, 20-2-81. GDF, DR1995:0280: 651 5/5, CPA-CCA.

101. J. Frazer to C. Price, 4 December 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

102. J. Frazer, 'Interactive Computer Aided Design Program Based on the Concept of Seeding Technique', ca.1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

Figure 2: John and Julia Frazer (Cedric Price Architects, Systems Consultants), Intelligent Modelling System (Generator Model), ca.1980(?). Untitled Document Folio: John and Julia Frazer Personal Archive.

Cedric Price's Generator, even if unbuilt, had acquired a notable position as the first intelligent building project.[100]

During that time, believing in alternative CAD methodologies, the Frazers continued to forward their research by developing the aforementioned three-dimensional model version which allowed non-orthogonal forms, as well as a general-purpose computational system. Towards the end of 1980, as proven by a letter from Frazer to Price, improvements were also made specifically to the Generator model, simplifying its appearance and enabling even more variation. In this connection, it is noticeable that in December, Frazer had asked Price to provide a reference to support an application to the Science Research Council.[101] According to Frazer's application that was sent to Price, the seeding method (i.e. an alternative computer-aided technique that enabled interactive design, hence possessing broad potential) was to be applied, in that precise circumstance, to the design of industrial and agricultural buildings (to provide research on design decisions, etc).[102] Interesting was the fact that Frazer's letter made note of his recent bold achievements and its potential application, as well as the Generator model:

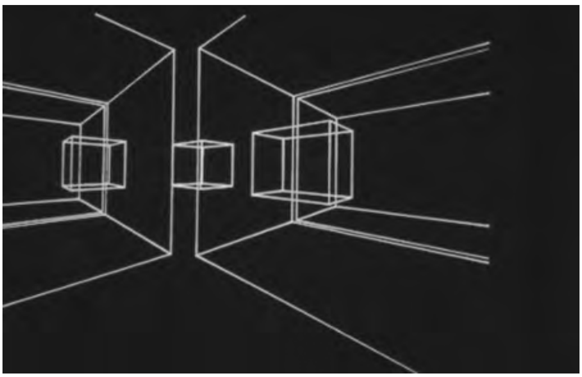

Figure 3: John and Julia Frazer (Cedric Price Architects, Systems Consultants), Intelligent Modelling System (Generator Model: screen view), ca. 1980(?).Untitled Document Folio: John and Julia Frazer Personal Archive.

> I have been developing some interesting and more complex three-dimensional models which are not specifically related to the Generator but which could represent almost anything. [. . .] I have also developed a great improvement to the generator model which abandons the pretty rainbow cable connections and reduces the number of pin-connections so that these are now all beneath the board, and furthermore, the cladding is dealt with as a series of slotted-in printed circuits boards which [. . .] allow, by use of a serial data transmission chip, up to 43 million different cladding variants to be encoded. [. . .] Would you like to see some photographs?[103]

Price's recommendation letter is extremely relevant too.[104] It explicitly acknowledged Frazer's originality and his singular contribution to the Generator project, having impressed Price far beyond his expectations. This also expressed Price's opinion of a CAD industry orientation that neglected the user and the coincidence of Frazer's technique with an 'anticipatory' design that he so much privileged. Price ended with an explicit association of the potentiality of Frazer's method-technique with a central need for future architecture:

> I would mention that while I have had some lengthy experience and involvement in Computer Aided Design I have not found anyone, or, indeed, any agency that can extend such work so beneficially to the eventual users of the buildings concerned. This singular contribution has enabled the socially beneficial nature of this complex to be extended well beyond the range I had at first considered possible. Generally, Computer Aided Design both here and overseas has up till now been extremely limited both in its application and, more seriously, in the emphasis on the usefulness to the producer (architect or designer) to the neglect of the real client – the user. Frazer's 'seeding' method overcomes this, and through meticulous anticipatory user-design potential, meets a central need in worthwhile future architectural design and production.[105]

The intelligent modelling system thus promised to benefit any architect and user; and the Frazers' computational systems acquired a role that went beyond Generator. In this connection, it is noticeable that a month later, in January 1981, Frazer sent Price an invitation for his demonstration at the AA of a working prototype of the 'general purpose version of the system', stating that: 'An early prototype version [. . .] has been employed by Cedric Price as architect for the design of the Generator [. . .] currently under construction [. . .]'[106] (Later, as shall be described, exchanges between Price and Frazer continued to occur.)

7. Conclusive overview: towards a responsive architecture

At this juncture, it could be pointed out that Price had acknowledged the crucial role that the Frazers' systems had played in the project, and he believed in the idea of revisiting it. Frazer, in turn, pushed further his early research ideas and modelling systems towards a general-purpose version. (In short, Frazer's system, besides further enabling the Generator's intelligence, pursued new CAD methodologies that acknowledged interactivity and the involvement of the user.) He remained open to further developments concerning Generator too.[107]

103. See endnote 101.

104. C. Price to N.L. Williams, 8 December 1980. GDF, DR1995:0280: 651 5/5, CPA-CCA.

105. See endnote 104.

106. J. Frazer to C. Price, 6 January 1981. GDF, DR1995:0280: 651 5/5, CPA-CCA.

107. In this regard, it is pertinent that Frazer's 1980 article already emphasized that intelligent modelling had many applications in architecture and education, whose results were meant to 'improve interactive CAD techniques [. . .] a convenient method of data input [. . .] and better interaction between designer and client'. See reference in endnote 60. Frazer's stance in promoting a more interactive participation was somehow linked to concepts such as that of *Culture and Democracy* which constituted the title of a book that had been suggested to Price. He kept it inside a folder, marked with John Frazer's name and with the project number pertaining to Generator, which contained several papers from 1981 and a nautical brochure dated 1982, reflecting one of Frazer's interests. See the following material:

    Institute of Oceanographic Sciences, *MIAS: News Information. Marine Information and Advisory Service*, 5 (February 1982). GDF, DR1995:0280: 651 4/5,CPA-CCA.

Hugh Dalziel, *Culture and Democracy: The Struggle for Form in Society and Architecture in Chicago and the Middle West During the Life and Times of Louis H. Sullivan*, Ducan: The Bedminster Press, 1965 (photocopies) GDF, DR1995:0280: 651 4/5,CPA-CCA.

The papers were authored by Frazer and colleagues from around 1981, and focused on the computational technique's development, its role in simplifying three-dimensional data input, the personalization of shape processing, and the clarification of problem-formulation strategies in design. See the following material:

J. Frazer, Julia Frazer and Peter Frazer, 'New Developments in Intelligent Modelling' (paper for *Computer Graphics 81* conference), ca.1981. GDF, DR1995:0280: 651 4/5,CPA-CCA.

J. Frazer, Julia Frazer and Peter Frazer, 'The Use of Simplified Three-dimensional Input Devices to Encourage Public Participation in Design' (paper for *CAD 82 Conference* in Brighton), 1982. GDF, DR1995:0280: 651 5/5, CPA-CCA.

J. Frazer, 'Three Dimensional Data Input Devices' (Text), undated. GDF, DR1995:0280: 651 4/5,CPA-CCA.

J. Frazer, Julia Frazer, Paul Coates and Anne Scott,, 'The Commercial and

In fact, despite the Generator project's temporary suspension, exchanges between Price and Frazer continued to be made. For instance, in mid-February 1982, Frazer asked for permission to refer to the project in a paper presentation on some of his modelling systems in the United States, and he took the opportunity to ask: 'what the current status of this project is and how I should refer to it – in the past? Or in the future?'[108] Months later, in November, he sent a letter regarding a computer animation film competition entry.[109] Price replied, 'I like the idea and have forwarded your letter [. . .]'[110] It is the fact that Price's short engagement with his computer consultants had revealed great potential for his project development. Although recognizing that the project was in a state of suspension, he believed that it was not completely abandoned and so took the chance to forward Frazer's letter to Gilman.[111] This probably did not end up happening;[112] nevertheless, it shows that even though the project was at that point in suspension, Price and Gilman kept in contact.[113] Throughout the 1980s, Generator's design research, which had led to the birth of the intelligent building, became an influential project among a number of architectural students.[114]

The Generator also had an important presence in Price's 1984 outstanding exhibition at the AA, and in its associated publication. The latter included an article by Royston Landau, which equated Price's architecture with 'a philosophy of enabling'; Landau acknowledged the importance of Generator with precision, and stated that 'Price's role for technology is intimately linked with his critique of Architecture.'[115] Generator showed a sophisticated use of technology and a seminal exploration that pursued Price's aims:

> An intelligent environment must have the capacity to learn and a memory and an ability to respond. Since the Fun Palace, Price's architecture had possessed a capacity to respond, that is, it could react formally or mechanically to a given stimulus [. . .] But an architecture which did not simply react but which learned, remembered, when necessary re-learned, and then responded appropriately is clearly what his approach was leading towards [. . .] Generator project was [. . .] one of the first major investigations into an artificially intelligent architecture [. . .] one which also serves, perhaps in the most sophisticated manner yet, the purposes of human enabling.[116]

The aforementioned interest in Generator shows the project's importance and relevance, and it suggests that the project would be revisited, as it was in the 1980s.[117] Cedric Price and the Frazers´ collaboration constituted an outstanding exchange between architecture and computational systems.[118] The Generator experience explored the impact of the new techno-cultural order of the Information Society in terms of participatory design and responsive building. At an early date, it took responsiveness further; and postulates like those behind the Generator, where the influence of new computational technologies reaches the level of experience and an aesthetics of interactivity, seems interesting and productive. As smart buildings began to proliferate, Spiller highlighted that it 'sets a benchmark against which most contemporary intelligent buildings [. . .] can be measured'.[119] And future smart buildings should advance towards ideas of IB that privilege human and machine.[120] Today, those experiences coincide with an architectural agenda marked by the need to trace roots for the existing dynamics interested in new information technologies and the scientific thoughts of complexity and emergence. It provides a ground for contemporary speculation on the future of architecture within a post-industrial and post-modern society. Frazer himself stated in 2003 that 'Generator still has much to say to those who believe that architecture should serve the users, and a new model might speak to a new generation who might yet realize the future of which Cedric Price gave us a vision.'[121]

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Notes Continued

114. See the following material: Linda Jones (CPA) to David Gosling (Sheffield School of Architecture student), ca.1983. GDF, DR1995:0280: 651 5/5, CPA-CCA.

     CPA, untitled (memorandum referring a contact from the student from Newcastle, Richard F.), 7 November 1988. GDF, DR1995:0280: 651 5/5, CPA-CCA.

     Hugh Peranean, unidentified title (Paper on smart buildings), ca.1985 (received at CPA on 13 June 1985). GDF, DR1995:0280: 651 1/5, CPA-CCA.

115. Royston Landau, 'A Philosophy of Enabling', Ron Herron et al. (eds), *Cedric Price Works II*, London: Architectural Association, 1984, pp. 9–15.

116. See footnote 115.

117. During that time, the Frazers continued to pursue their own research. Developments are described in Frazer's 1995 book. See:

     J. Frazer, *An Evolutionary Architecture*, London: Architectural Association, 1995.

     Furthermore, Frazer's Autographics received a number of awards.

     Autographics, 'Awards Received 1988–89', ca.1989. GDF, DR1995:0280: 651 5/5, CPA-CCA.

     The Generator research had constituted a productive experience for the Frazers and they remained in contact with Price and continued to share their developments and eventual applications for Generator, as well as challenging him to push the Generator's

Educational Impact of the Shape Processing' (paper for *Computer Graphics 81* conference in London), ca.1981. GDF, DR1995:0280: 651 4/5, CPA-CCA.

J.Frazer, Paul Coates, Anne Scott, 'Problem Worrying Program' (paper for *Themes in Systems Research* conference in Amsterdam), ca.1981. GDF, DR1995:0280: 651 4/5, CPA-CCA.

108. J. Frazer to C. Price, 15 February 1982. GDF, DR1995:0280: 651 5/5, CPA-CCA.

109. J. Frazer to C. Price, 17 November 1982. GDF, DR1995:0280: 651 5/5, CPA-CCA.

110. C. Price to J. Frazer, 19 November 1982. GDF, DR1995:0280: 651 5/5, CPA -CCA.

111. C. Price to H. Gilman, 19 November 1982. GDF, DR1995:0280: 651 5/5, CPA-CCA.

112. A letter, from around that time, from the Generator's client showed that he had personal concerns around various problems.

     H. Gilman to C. Price, 24 November 1982. GDF, DR1995:0280: 651 5/5, CPA-CCA.

113. They remained in contact during the following years, and Price even made informal suggestions concerning Gilman's property enclosure fences.

     H. Gilman to C. Price, 2 May 1988. GDF, DR1995:0280: 651 5/5, CPA-CCA.

computational research further. In this connection, it is noticeable that a Frazers' proposal for a new Generator model and Price's collaborations with the Frazers' design unit occurred in the late 1980s and early 1990s. See:

J. Frazer and Julia Frazer to C. Price, 28 April 1989. GDF, DR1995:0280: 651 5/5, CPA-CCA.

(See also J. Frazer, interview with the author, 22 March 2005.)

118. Frazer's book-idea of *An Evolutionary Architecture*, published in 1995, coincided, to some extent, with Price's idea of an architecture that could embrace a process of evolving simultaneously with the user and society. In this connection, with regard to Generator, one should recall how Price particularly searched for a 'responsive architecture', an idea that appeared as previously described in the description of the project that he sent to Frazer, as well as in an early text to which a note mentioning a 'redefinition of architecture' was attached. The current interest in Cedric Price's Generator project and Frazer's research is easily understandable. The Generator experience explored the impact of the new techno-cultural order of the Information Society in terms of participatory design and responsive building. See

C. Price, untitled (card with notes including 'Redefinition of architecture', and attached to the draft 'A History of Wrong Footing – The Immediate Past'), undated. GDF, DR1995:0280: 651 5/5, CPA-CCA.

119. See endnote 2.

120. Interestingly, So and colleagues' idea of IB, recently accepted in Asia, '. . .based on user needs instead of the building itself' coincides with Generator's essence. See Albert T.P. So, Alvin C.W. Wong and K-C. Wong, 'A New Definition of Intelligent Buildings for Asia', *Facilities*, 17: 12–13 (1999), Bradford, pp. 485–91.

121. See endnote 46.

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The asymmetry between discoveries and inventions in the Nobel Prize in Physics

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Abstract
This paper presents an empirical study on the frequency of discoveries and inventions that were awarded with the. More than 70 per cent of all Nobel Prizes were given to discoveries. The majority of inventions were awarded at the beginning of the twentieth century and only three inventions had a direct application for society. The emphasis on discoveries moves the Nobel Prize further away from its original intention to reward the greatest contribution to society in the preceding year. We propose to strengthen the role of inventions for the Nobel Prize, which would encourage inventors to tackle important problems, such as global warming or the gap between the first and the third worlds.

Keywords
Nobel Prize in Physics
inventions
discoveries
global warming social application

Introduction
Alfred Nobel mentioned in his testament that the interest of this fund 'shall be annually distributed in the form of prizes to those who, during the preceding year, shall have conferred the greatest benefit on mankind' (Nobel). More specifically, one part is given 'to the person who shall have made the most important discovery or invention within the field of physics'. Nobel did not further define the terms 'discovery' and 'invention', but the *Meridian-Webster Online Dictionary* defines invention as 'a device, contrivance, or process originated after study and experiment' and discovery as 'to obtain sight or knowledge of for the first time'. It is likely that Nobel would have agreed to these generally accepted definitions.

The fundamental difference between an invention and a discovery is that the result of an invention is an artefact and the result of a discovery is a theory. Both require prior theories, a process of experimentation and both have a utilitarian function. A new microscope, for example, might allow a better measurement of a phenomenon and is therefore more useful than all previous microscopes. In the same way, a new theory that predicts a phenomenon better than previous versions is more useful. Discoveries also depend on inventions and vice versa. The times where one's own eyes were sufficient for relevant observation are long gone. Physics requires sophisticated machines, such as the particle accelerator at the European Organization for European Research CERN Laboratory or the Hubble Telescope in the orbitaround earth. Without these artefacts it would be extremely difficult to gain newinsights. But without a thorough understanding of magnetism and optics it would also be impossible to build these artefacts in the first place. Discoveries and inventions are mutually dependent.

It appears to us, however, that discoveries are much more respected by the scientific community than inventions. The Nobel Prize is the most esteemed scientific acknowledgement and its selection procedure depends heavily on the science community. Its social and political aspects have been discussed in detail (Friedman 2001). Various analyses are available that discuss the distribution of prizes across subfields, age and religion of the laureates, and the time interval between the actual work and its acknowledgement (Karazija and Momkauskait 2004; Zhang and Fuller 1998). The Nobel Prize offers a strong historical account of science and also systematic data (Shalev 2002). The Nobel Prizes form a solid and systematic data with which to answer our research question as to whether discoveries are more esteemed than inventions by the science community.

Method

We collected the short summaries of the Nobel Prize in Physics from the years 1901 to 2004 from the Nobel Foundation website. Even though certain prizes caused considerable debate and social and political issues cannot be excluded from the nomination procedure, it can be assumed that any of these biases would have affected discoveries and inventions equally.

The list of prizes was compiled into a questionnaire that asked the participant to classify each prize as either a discovery, an invention or both. In addition an 'I do not know' option was offered for every question. After reading the instructions and Nobel's testament, four academics were asked to fill in the questionnaire. A reliability analysis across the four judges resulted in a Cronbach's Alpha of .733, which gives us sufficient confidence in the opinions of the judges. The modus from the four classifications for each prize was taken. If, for example, three judges classified a certain prize to be a discovery and one classified it to be an invention, the prize would be considered a discovery. Two variables were used to reflect this transformation: 'i' for invention and 'd' for discovery. In our previous example, 'i' would receive a value of zero and 'd' would receive a value of one. These two variables are necessary, since the modus operation could also result in a prize to be both a discovery and an invention. In that case both 'i' and 'd' would receive a value of 0.5. No instance occurred in which the modus operation resulted in an 'I do not know' classification. Furthermore we calculated the delay of each prize by subtracting the year of the actual work from the year in which the prize was given.

Results

We summarized the number of invention prizes and discovery prizes by decade and calculated the proportion of discoveries and inventions based on the values for 'i' and 'd'. Figure 1 shows that there have always been more Nobel Prizes awarded to discoveries than to inventions. On average, 77 per cent of all Nobel Prizes in Physics were given to discoveries and 23 per cent to inventions.

It can also be observed that the delay between the origin of the work and its acknowledgment is increasing. Figure 2 shows that the delay has almost tripled over the last century.

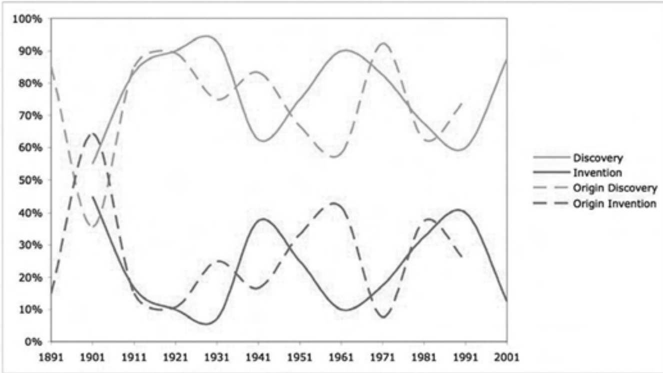

Figure 1: Proportion of Nobel Prizes in Physics given for discoveries and inventions per decade.

Figure 2: Delay in years between the origin of the work and its acknowledgement per decade.

To test this impression we conducted an analysis of covariance in which type (invention or discovery) was the fixed factor, year (year of the award) the covariant and the delay time the dependent measurement. While the type of prize had no significant influence on the delay ($F(2,111)=1.848$, $p=.162$), year did have a very significant influence ($F(1,111)=32.2$, $p<.001$).

Discussion

Nobel did not specify in what proportion prizes should be awarded to inventions and discoveries. By preferring discoveries, the Nobel Foundation does not therefore violate Nobel's testament. Still, it is obvious that the academic community strongly favours discoveries. A closer look at the awarded inventions reveals that eleven out of the total of seventeen inventions (64 per cent) can be considered measurement instruments.

Nobel specified that the prize should be awarded to inventions within the field of physics. The majority of inventions that the field of physics awards are tools upon which their discoveries depend.

Other extremely beneficial inventions for mankind, such as the paper clip or the condom, did not receive the Nobel Prize and likely never will. This is mainly due to the fact that physics does not consider them to be part of its field. Even more technically sophisticated inventions, such as aeroplanes or mobile phones, did not receive the prize. Only three awarded inventions had direct practical applications: the gas regulator controlled buoys by Nils Gustaf Dalén were thereafter used in lighthouses, the transistor by Shockley, Bardeen and Brattain is widely used in electronic devices, and the integrated circuit by Jack Kilby made personal computers possible. It can also be observed that four out of six inventions were awarded at the beginning of the century between 1901 and 1912. It appears that the activity of inventing was split off into the field of engineering. At the same time we can confirm R. Karazija and A. Momkauskait's (2004) findings that the delay between the origin of the actual work and its award has significantly increased in the last century. In the last decade the average delay has amounted to 26 years. We could not find a significant difference between discoveries and inventions in the delay between the origin of the work and its resulting award. However, Nobel's testament clearly states that the prize money should be 'annually distributed in the form of prizes to those who, during the preceding year, shall have conferred the greatest benefit on mankind'. Since the statute of the Nobel Foundation does not allow the prize to be awarded posthumously, it will become increasingly difficult to choose suitable candidates if this delay-trend is continued. At some point, the committee will only be able to recommend dead scientists. The increase in the delay time together with the fact that barely any awarded inventions have a direct application, and therefore benefit, for society moves the Nobel Prize further away from its original intention to reward the greatest contribution to society. Refocusing the Nobel Prize on inventions might help to lead physics to results that are more easily transferable to direct benefits for society. The award given to Jack Kilby for the development of the integrated circuit is a good example. Modern computers certainly contributed to the field of physics, but they also had a great impact on society. The invention of the electric telephone, patented first by Graham Bell, can be considered a missed opportunity to acknowledge an important invention that brought the world closer together and helped to form a global consciousness, but there is still hope for Tim Berners-Lee's invention of the World Wide Web.

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A cybernetic observatory based on panoramic vision

André Parente and Luiz Velho

Abstract
This article is about an original virtual reality and multimedia system named Visorama, with dedicated hardware and software aimed at the following fields: digital art, entertainment, historical tourism and education. On the software level, the Visorama system includes the research of a new methodology to build and visualize a stereoscope panorama; a high-level language to provide a transition mechanism between panoramas (wipes, blending, etc.); and multiple-resolution panoramas to assure the image's resolution level. On the hardware level, the Visorama simulates an optical device that uses a binocular display to show the image generated by the panorama system. This display is attached to a support base that can rotate around vertical and horizontal axes, which have high-resolution sensors that together capture the current viewing orientation. In addition, three buttons allow the control of zoom angle and the generation of discrete events. This form of direct manipulation of the viewing parameters provides a natural interface for virtual panoramas. On the level of its applications, the system as a whole is designed to promote a more natural interaction with the real space, since its basic characteristics allow the possibility of visualization of the real through a virtual window. The viewer travels in space and time following the several link points contained in it, as various possible navigation routes.

Keywords
virtual reality
panoramic image
Visorama
cybernetic observatory

1. Introduction
We can say that there had been, in this last quarter century, a new panoramic image vogue: new photography, cinema and video equipment and devices were created. Among them, we point out a new computer-based visualization method based on panoramic images that has originated several *programs* that allow for the creation of the so-called 'virtual visits'.

Several exhibits and publications have been produced, having the panoramic image as the main theme: *The Panoramic Image* (John Hansard Gallery, Southampton, 1981), *The World is Round* (Hudson River Museum, 1987), *Panoramania* (Barbican Art Gallery, London, 1989), *Panorama – La Collection Bonnemaison* (Actes Sud, Arles, 1989), *Panorama des Panoramas* (Centre National de la Photographie, 1991) and *Sehsucht* (Bonn, 1993). Recently, *Expo 02* (2002), in Switzerland, presented six giant panoramic installations, two of which were set up in a building erected by Jean Novel in Lake Neuchatel.

Interest in panoramic photography has been renewed through the photos by David Hockney, Andrew Davidhaze, Joseph Kudelka, Jeff Guess, Jeff Wall and Bernard Bonnamour. Important contemporary artists have worked with panoramic installations: Michael Snow, Gary Hill, Stan Douglas, Doug Aitken, Pipilotti Rist, Sam Taylor-Wood, Egbert Mittelstädt, Ann Hamilton and many others. In the field of new medias, artists like Jeffrey Shaw, Michael Naimark, Christian Ziegler, Du Zhenjung, Masaki Fujihata, André Parente, Luiz Velho and others have presented several immersive and interactive installations. Some of these installations recreate the cinematographic device in all dimensions, adding to the cinematographic image the immersive architecture of the panoramas and the interactive language of the new computer interface.

For us to be able to understand the extent of the issues raised by interactive panoramic installations, we need to look back to the problems raised on the one hand, by the panoramic image, with the advent of panoramas and, on the other, situate the immersive and interactive audio-visual installations within the history of the wide-screen cinema.

2. Panoramas

A *panorama* is a type of mural painting built in a circular space around a central platform where spectators can look around in all directions and see a scene as if they were in the middle of it. It was patented by Robert Baker in 1787 and at that time was a very popular representation of landscapes and historical events. The drawing below shows a section in a three-stoey panorama building dating from 1793.

Panoramic images bear an impressive history since the panorama comprised the first imagetic mass device, and prevailed in Europe during the nineteenth century, even before the cinema and photography.

The panorama is the first imagetic mechanism of tele-presence. The panoramas simulated – through a 360-degree painting, gazed at from a central platform – 'represented' reality with such perfection that the spectator felt as if he were actually there, surrounded by it. The premises created by the panoramas were similar to the ones created by the most sophisticated simulators, which provided the simulation of a real experience, namely, in the case of panoramas, the experience of visiting a place.

In fact, the panorama represents an epistemological breakthrough in the escopic regime of images as important as the emergence of pictorial abstraction. It is pertinent to note that modern art arises from a transformation detected by Diderot in eighteenth-century French paintings, with the works by Greuze, David and Chardin. According to him, these paintings are strictly related to an effort to combat the theatrical nature of representation and rationalization of figuration, caused by the remnants of Cartesian rationalism, evoking an unbound image intended to be looked at by the eye of reason, thus denying the presence of the spectator.

Modern art dealt with the place of the spectator through two different ways: the aesthetics of opacity and the aesthetics of transparency. In the first case, painting would become more and more impenetrable, with the use of impressionist strokes and later on, of abstraction. In the second case, on the other hand, painting would do everything to bring the spectator inside the picture. Both these conceptions deal with the problem of the presence of the spectator, who becomes the observer, and strengthens the tension between subject and object, situated at the origin of modernity. Impressionist painting, and later on abstract painting, would take radical measures and take to the last consequences the aesthetics of opacity, while panoramas are the perfected mechanisms of the aesthetics of transparency, since their main objective is to bring the spectator into the image.

The evolution of the panorama is related to the betterment of different panoramic immersion mechanisms with the aim to take the spectator to the centre of the represented action. A first modification was introduced by Charles Langlois, in 1831, when he replaced the central platform, from where the spectator looked at the painting along 360 degrees, with a ship, from where the spectator looked at the battle of Navarin, represented in the *Panorama de la Bataille Navale de Navarin*.

Certain variations of panoramas used other kinds of architecture. The American panoramas, nicknamed *moving pictures* or *moving panoramas*, differed from European ones by their non-cylindrical shape. Their great innovation consisted in replacing the traditional platform with a device that simulated a ship or a train, so as no longer to create simply a visit, but a real trip. Once placed there, the spectator took part in a trip along the Mississippi or the Grand Canyon, for example, through a large flat painting that ran along the window before which he remained for hours (it has been said that some pictures were more than three miles long). The simulation of movement became more effective when moving pictures started to adopt cinematographic images, captured from windows of trains and ships.

In 1900, at the Universal Exhibition in Paris, some remarkable panoramas were shown, transforming the panorama into a complex installation, half way between theme park, cinema and advanced systems of virtual reality. The Mareorama case is well documented. With *Mareorama*, the spectator would travel among the more representative landscapes between Marseille and Yokohama, including Naples, Ceylon, Singapore and China. The platform, disguised as a transatlantic ship, 70 metres long and capacity of up to 700 people, would lie on a Cardan suspension system to simulate the swaying of the waves. Actors would execute navigation manoeuvres while a ventilation system diffused marine scents and the light was altered creating an effect of dusk at the end of the trip. A truly complete show that was nothing short of anything found at current theme parks.

Cineorama, patented by Grimoin-Sanson in 1897, is a mechanism formed by a circular building with circumference of 100 metres. Its white walls function as a continuous screen on which the images of ten projectors form an apparently single image. The centre of the room is occupied by a huge balloon basket equipped with routine accessories, anchor, ropes, counterweight and ladder. The ceiling is covered by a curtain imitating an aerostat envelope. The ten synchronized devices are fixed under the basket and, once the room is darkened, they project views of take-offs, balloon trips and landings, the last obtained by rewinding the film.

All these variables have certain common aspects. The spectator remains in a sort of 'environment' represented by images 'projected' around him. The interaction offered by the panoramas is naturally accepted by the spectators, since it is very similar to the way we are used to perceiving the world, as if we found ourselves in its centre, like bearers of affections and sensations that support what we see.

The panoramic image displays its own historical tradition, set in two very distinct trends: the architectural panoramas and the iconic panoramas, with the photographic ones being the best known. The photographic panoramic images are true moving images, even before the movies. The panorama allows us to re-stage the history of art and of the technical image since it deals with a system that is the origin of many fundamental questions. Immersiveness and a new type of visibility, amongst others, are questions that are highly dependent on the observer's appearance on stage. In this sense, it seems that the panorama comes to render problematical the relationship between image and spectator.

3. Virtual panoramas

Recent advances in image-based rendering techniques have enabled the real-time simulation of panoramas on the computer, which we call *virtual panoramas.*

In a virtual panorama a digital image is 'painted' onto a *panorama surface* $S \subseteq \Re^3$ using environment mapping techniques. A virtual camera is then used to observe the surface interactively. The user is allowed to rotate the camera around its nodal point and change its field of view. The image to be projected on the surface is called the panoramic image . This is illustrated in Figure 1.

The panoramic image represents the projection of the environment on the panorama surface. The virtual panorama systems provide tools for the creation of these images from photographs. These could be taken from the real world or from a modelled environment.

After being mapped on the panorama surface the panorama image can be interactively observed on the screen, as if the user were at the location where the pictures were taken. The process just described involves two projections: (1) the projection of the environment on the panorama surface; (2) the projection of the panorama surface onto the virtual camera screen.

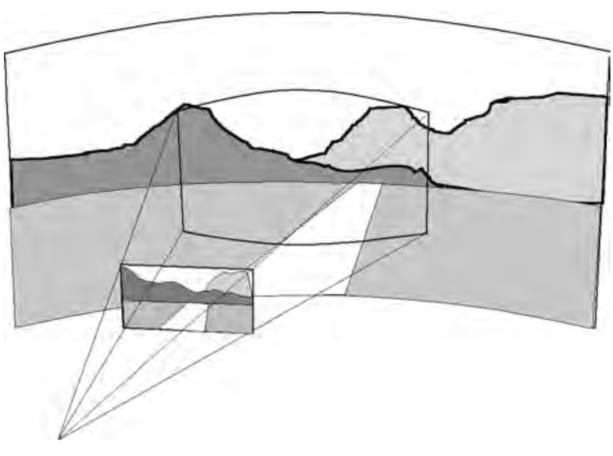

Figure 1: A virtual camera observing a panorama.

The panorama surface should have a simple geometric shape (cylinders, spheres and cubes) to facilitate these two environment projections.

A virtual panorama system has two major components: an authoring environment and a visualization system. The first allows the creation of the panoramic image. The second performs the projection of the panorama surface onto the virtual camera interactively, allowing the user to pan, tilt and zoom with the camera.

The rebirth of the panoramic image through virtual panoramas (the photorealistic virtual environments), leads us, for the first time in the history of technical images, to reposition the age-old opposition between images and models, between the sensitive and the intelligible.

In fact, the interactivity of new panoramic installations will potentialize what already existed in embryo in ancient panoramas and that represents an even more radical transformation in the relation between the image and the spectator, initiated by modernity. In modern works, the spectator cannot be idealized as a subject of knowledge: his vision evokes the sensitive and carnal eye, since it becomes a support for the sensations produced by the aesthetics of opacity and transparency (the first focuses on sensitive aggregates, the second on a world of sensations). But the contemporary work and its inherent interactivity presupposes an increased complexity of this relation. In fact, the contemporary work, instead of the modern one, does not pre-exist in its interaction with the spectator. The installation allows the artist, the film-maker and video-maker to spatialize elements that constitute the work. The term indicates a kind of creation that refuses the reduction of art to an object to better consider the relation between its elements, among which, many times, is the spectator himself. The experience of the work by a spectator constitutes a determinant factor. The work is a process, its perception takes place during a journey. Engaged in a journey, implied in a mechanism, immersed in an environment, the spectator participates in the work's mobility.

The mechanism designates the form through which the material presentation of the work is inscribed in a systemic and structured gaze. Since the end of the 1950s, art started to elaborate the concept of work as a situation, an environment, an architecture, a mechanism. That is, an installation that engages the physical participation of the spectator, who becomes one of the work elements.

More recently, the projection of moving images went on to constitute the main elements of work. The participation of the spectator, by means of advanced technologies, has been gaining greater amplitude. In this case, not only does the spectator inhabit the work but he can interact with it, transforming it with his action. The installations that use immersive and interactive panoramic mechanisms are interesting to the point that they act for the convergence of contemporary art, advanced technologies and cinema as new media.

Finally, with the panoramic image, the hybridization between images reaches its paroxysm: between painting and virtual reality (by the immersiveness of the panoramas); between the artistic image and the installation (which requires spectator participation); between photography and the cinema (a chronotopic image, which is made in movement); between photography and the photorealist virtual environments (the recent image-based visualization systems); between the image and the Net (hypertextual panoramic image).

The panoramic image bears a number of basic characteristics: an extrafield lack, but the presence of framing (= the total field idea pursued by the panoramic image); a single image, but a multiplicity of perspectives (= the rotation of the camera creates a multiplicity of perspectives); a single take, but a inscription in time (the image is an image-movement, which corresponds to the sweep performed by the camera); the illusion of tele-transportation instituted by the architectural panoramas: the spectator feels transported into the universe represented by the image.

4. The Visorama hardware

Visorama's main hardware components, their relationships and functional groupings are shown below. They can be classified into three hardware subsystems as shown in Figure 2: input subsystem, output subsystem and control subsystem.

The *control subsystem* is basically a desktop computer with the necessary interfaces for communicating with the other hardware components in the input and output subsystems. This computer stores all information about the virtual environment. It runs software programs that use this information and user data obtained from the input subsystem to generate feedback data for the output subsystem. This real-time process imposes a minimum speed constraint on the choice of processor used since it must be able to take user input and generate appropriate output without introducing any lagging effects. It is also important that current virtual panorama systems run on this platform, since we intend to use them as part of our system.

The control subsystem generates two types of data for the output subsystem: image and sound. The first type is sent to the binocular display and the second to the stereo sound equipment.

The binocular display (see figure 3) is an immersive display device that resembles common binoculars but, instead of having a set of lenses, it has, for each eye, an eyepiece and a miniature CRT screen. The images displayed by these screens appear to the user as if they were the projection of lenses in common binoculars. Each CRT screen is connected to a video output port on the computer. If two output ports are available, each screen can be

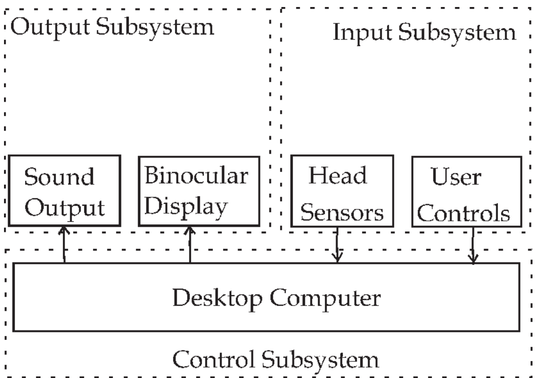

Figure 2: Hardware components.

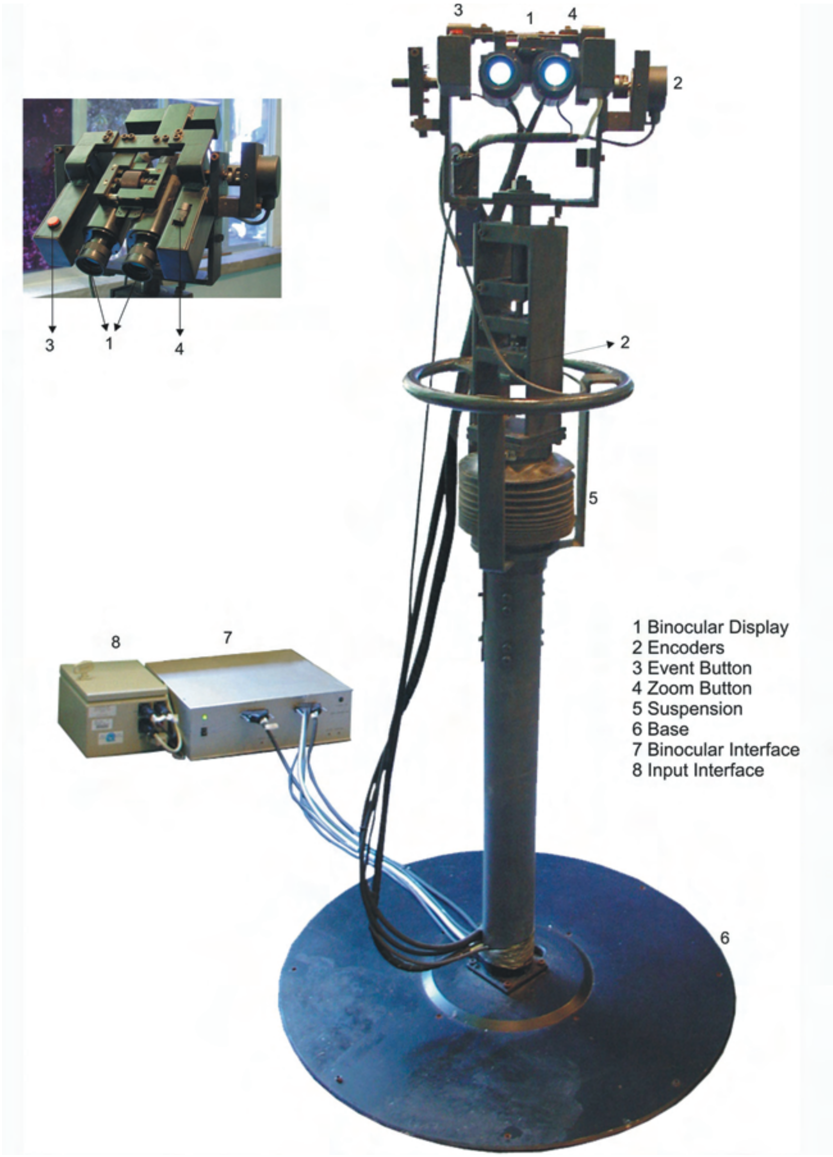

Figure 3: The Visorama prototype.

connected to either one or the other', and a different image can be displayed for each eye. Although this allows stereo panoramas to be displayed, the first version of the Visorama system does not use this functionality.

The stereo sound equipment is basically a pair of headphones that are connected to a stereo sound output port in the computer. Alternatively, speakers can also be used, but these have the disadvantage that the sound of the real environment could be confused with the system's output sound, resulting in a loss of auditory immersibility. By having a stereo system, different sounds can be output to each channel in order to simulate three-dimensional sound in panoramas where sound sources are associated to a specific viewing direction.

All output generated by the control subsystem is a function of the input data it receives from the input subsystem and from authoring information. This input data takes two forms: viewing direction data, which is generated by a rotating head and a set of sensors, and user control data generated by a set of additional controls.

The rotating head provides a direct manipulation of the viewing direction on the panorama. Potentiometers are attached to the two rotating axes of the head to capture the binocular display's movement and send it to the control subsystem.

The input subsystem has a set of additional controls: two buttons and a potentiometer. The potentiometer is used, in most cases, as a control of zooming angle. One of the buttons is used to generate discrete actions to the system, such as selecting an object on the panorama. These two controls are easily accessible by the user, since they will be heavily used. Note that these two controls and the potentiometers on the rotating head allow the execution of positioning, selecting and quantifying tasks. The only task that cannot be done is entering text, which is not required for this specific system. The remaining button can be used to take the system into a control mode for specifying settings such as volume control.

A simple circuit polls all input devices periodically for their values. It sends this data to the control subsystem, which must generate the correct feedback to the user as specified by the creator of the virtual environment. This is achieved by the system's software components.

5. The Visorama software

The system software program can also be divided into three main functional modules: input, output and control. These three modules and their relationships are illustrated in Figure 4. The input module takes all data from the hardware devices and sends it to the other software modules. The output module takes this data from the input module and command data from the control module and generates all image and sound output. Finally, the control module examines input data and, if appropriate, sends commands to the output module.

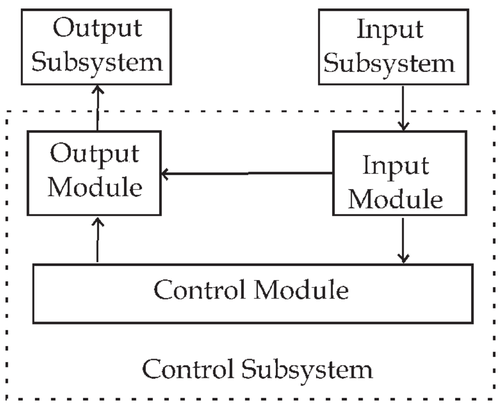

Figure 4: Modules and their relationships.

5.1 Input and output

The input module reads the data that arrives at the communication port. This data is then translated into a format that can be understood by the remaining modules. The rotation sensor's data is translated into two angles, pan and tilt, the potentiometer into a percentage value, and the push buttons into a binary value. By having this translation done by the input software, the remaining software components do not have to be modified when some input hardware is changed. These values are then passed to the other software components.

The data is passed to the control module by putting all arriving data into a specific memory location. If the reading rate of the control module is slower than the writing rate of the input module, data is overwritten. If a button is pressed, however, new data is only written when the old one is read, so the exact position of where the button was pressed is not lost.

For the output module, only the position and zooming data are transmitted module, since push buttons have no effect. These values are sent directly to the output software so it can immediately generate the rotating and zooming feedback on the virtual panorama. In this way, any delays that could be introduced by the control module does not affect the response time of the panorama regarding movement and zooming actions. Keeping this output coordinated with the binocular display's movement is fundamental to the immersibility provided by the system, since any lagging effects introduced in this process could confuse the user. Because no button data is passed to this module, information is overridden if the reading rate is slower than writing rate.

The output module has two components, the image generation component and the sound generation component. The image generation component displays the virtual panorama, static images or three-dimensional objects, which are all combined into a single output.

Any existing virtual panorama system can be used if it has the following functionality: displaying images and three-dimensional objects on top of panoramas and has an API that can be used to control the display of virtual panorama. This component receives commands from the control module determining which panorama, images or three-dimensional objects are to be displayed, and a few other commands. It then loads the appropriate files from disk and displays them. The viewing direction and zooming angle are obtained directly from the input module, and are updated each time a new set of data arrives, providing the correct feedback.

The sound generation component uses system resources to play sound on the hardware sound output subsystem. An environment like Apple Quicktime is used as a basis for the sound output component. This component takes commands from the control module that determine which sound files should be played and the current position in the sound files, as well as common audio commands such as play, pause, stop and volume control.

5.2. The Visorama system at work

The commands generated by the control module are based on data taken from the input module and from a file that stores authoring information about the virtual environment. This information relates input sequences to their corresponding feedback, as specified previously by the author of the environment.

The internal structure of the Visorama software is conceptually equivalent to a state diagram. Using this representation, the system is always at a known discrete state and a number of events are specified that cause the system to transition to a different state. A transition is defined by its source and destination states, a set of events that cause the transition to occur, and a set of actions that should be executed when the transition is in effect. A transition should be executed if one of its conditional events is true. The control module implicitly defines states by the set of all transitions that leave from it.

Events are defined as a Boolean expression whose elements must be a function of the module's parameter space. This space is the set of all combinations of pan, tilt and zooming angles, button states and system timers. The first three parameters can be composed into a single parameter, the viewing position, so they are treated as a point in a three-dimensional space, the viewing space, which defines a certain viewing configuration. Given these parameters, basic events can be represented by regions in viewing space, the button state and a timer. We say that a region in viewing space is true if the current viewing position is inside it, a button is true if it is pressed and a timer is true if it has finished. Events can then be specified by a general Boolean expression involving an arbitrary number of regions, buttons and timers.

Actions can be specified to be executed while a transition is taking place. The actions that can be executed with the available virtual panorama systems are changing the current panorama; altering the current viewing parameters; playing, pausing, stopping or jumping to a point in an audio file; showing or hiding an image or three-dimensional object; and starting a timer. Other interesting actions should become available in the future, for example, interpolating smoothly between two panoramas.

A state diagram that represents a virtual environment is used to drive the control module. Its execution is basically a single loop where it reads input parameters and checks if any event that causes a transition occurred. When this happens, it executes the actions specified for the transition and replaces the current state by the transition's destination state. This implementation provides a simple and efficient way of generating the appropriate output given the system's input.

Despite its simplicity, the software implemented as a simple state diagram would be memory inefficient due to the huge number of states that would have to be created in a typical virtual environment. Some simple modifications can be made to the state diagram to reduce the explicit number of states, thus reducing the memory necessary to store the diagram. One such modification would be to allow the specification of actions to be executed when states are entered or left. This is equivalent to specifying an action for all transitions in or out of a state. One example where that might be useful is to start a timer every time a new state is entered: in that way events can be easily specified relative to the amount of time the system is in a state. Another possible extension would be to allow additional state variables to be used, and have tests on them as part of the Boolean expressions that define events. As a result, the same original event could cause a transition to different states depending on the value of these variables. An additional value could be created, for example, to represent the number of times an event happened.

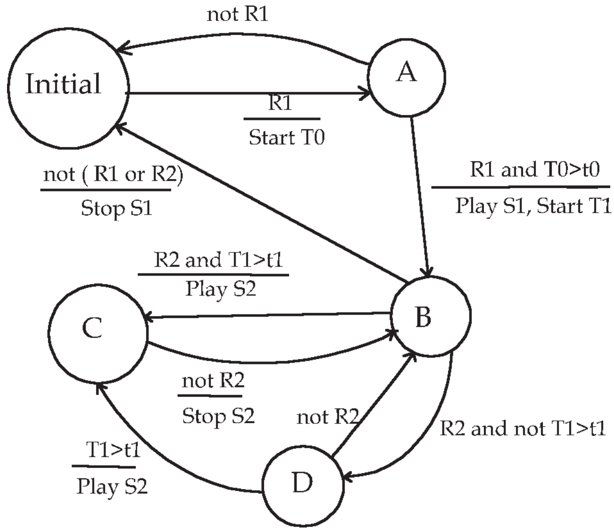

Figure 5: State diagram for a sample interaction.

The main problem with the approach based on state diagrams is the tedious process of creating the diagram to specify complex interactions. The approach is powerful in the sense that it can represent any interaction possible with virtual panoramas, and allows an efficient implementation. But as interactions become complicated, it is not intuitive for the author which states and transitions should be created. To illustrate a typical state diagram used in this system, Figure 5 shows a state diagram for the following interaction specification: from an initial state, if the user views a region R_1 for more than t_0 seconds, play an audio S_1 of that region with duration t_1. If user zooms into region R_2 and if S_1 has finished playing, then play another audio S_2. If it has not finished, wait for it to finish and then play S_2. If at any time the user leaves regions R_1 or R_2, stop audio S_1. If at any time the user leaves region R_2, stop audio S_2.

To relieve authors from having to specify complex state diagrams, and still be able to specify the complex interaction tasks possible with this system, we intend to develop an authoring environment that provides higher-level primitives for the specification of interaction tasks.

6. Authoring in the Visorama system

The Visorama system enables unique forms of interaction between the user and the virtual environment not available in current multimedia and virtual reality systems. It provides a new language for the communication from the user to the system and from the system to the user.

The immersibility provided by the system enables users to naturally navigate through the environment looking for the information that most interests them. As they do that, they seamlessly trigger numerous events that change the state of the environment. This does not happen in current multimedia systems, where all events are explicit and it is very obvious to the users the points on the navigation where they have to make decisions. Through this seamless navigation, it is possible for the system to estimate which parts of the virtual environment most interest the user (by analysing how long they look at a region, or how much they zoom into a certain area). This information can be used, for example, to guide the user through the environment, providing more information about areas that seem of more interest, and providing hints of next places to be visited. Two different users examining the same area could be given different information depending on the path they have followed to get to this point.

These are just a few examples of the new interaction possibilities with the system. All these forms of interaction define a new language that can be used by authors to create virtual environments in Visorama. To help them explore these possibilities, we define a set of basic language elements and operations for composing them. These elements and operations define a language that is at the same time complete, enabling the creation of most forms of interaction possible with the system, and effective, which can be easily learned. The elements and operations should have a known representation in terms of state diagrams so that a sentence in this language can be converted into a state diagram description of the system, which can, in turn, be used by the control module.

In addition to defining an authoring language, we implement an authoring environment for users to create virtual environments using this language. We define a scripting language that represents the interaction language, and define a set of semantic and syntactic rules for the specification of a virtual environment. Therefore a script can be written that is converted into a state diagram representation.

7. Installations and projects

Visorama has been publicly shown and demonstrated in congresses, workshops, shows and international exhibitions at research centres and major museums, among which we highlight two public installations. One during the *2ª Mostra Internacional de Realidade Virtual* (*2nd International Virtual Reality Show*) at the Universidade Cândido Mendes in 1999, when it was elected the most interesting system by the visitors. And during the exhibition *Paisagem Carioca* at the Museum of Modern Art (illustrated in figure 6), Rio de Janeiro in 2000, there were long queues to see it at the weekends.

Figure 6: Paisagem Carioca *(Museum of Modern Art, Rio de Janeiro, 2000).*

7.1 Figures in the landscape installation

This comprises an interactive audio-visual installation in which the spectator, using the Visorama, interacts with images which tell the story of the landscape. Upon interacting with an urban scene (the first navigation level), the spectator perceives, little by little, that he is before a mosaic

Figure 7: Figures in the landscape.

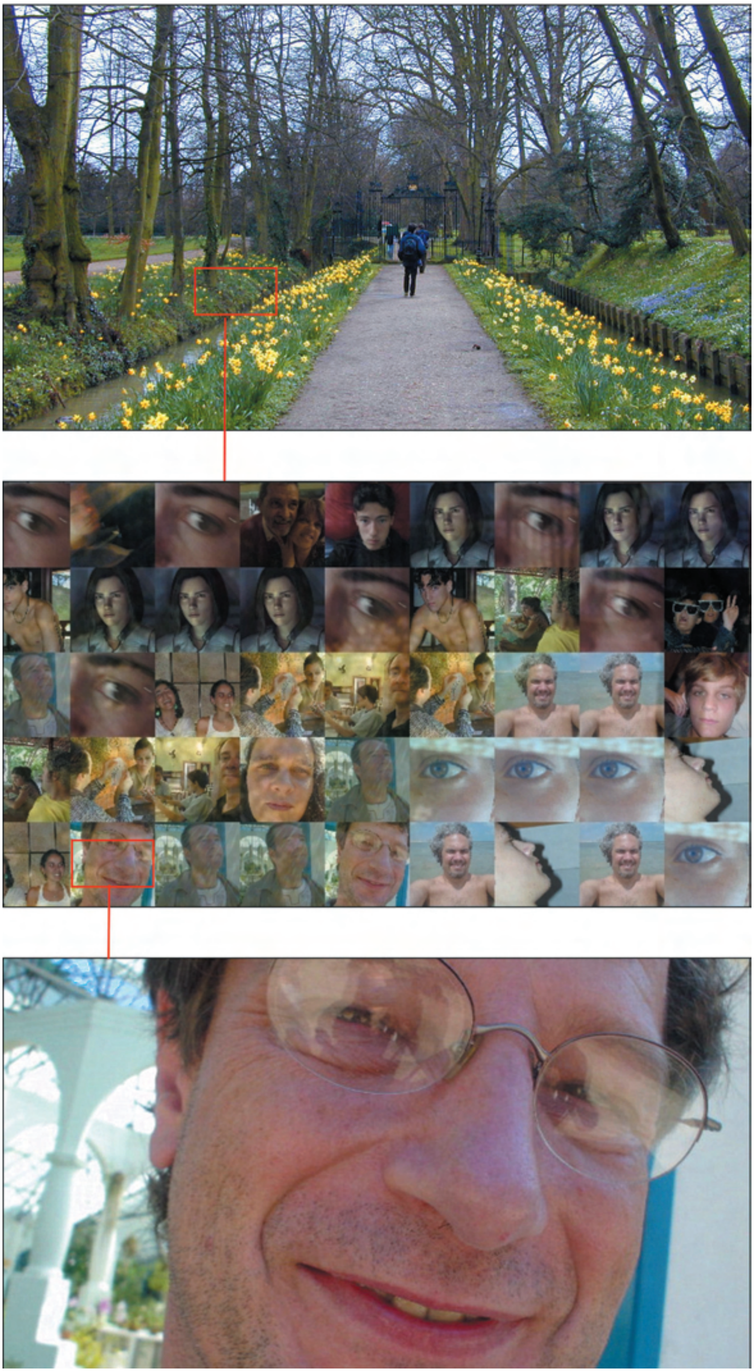

Figure 7: (Continued)

image that hides hundreds of other images containing other levels of navigation (as showed in figure 7). The landscape and faces seen comprise part of the story of the characters that inhabit the scene initially displayed. The installation mixes scenes and faces, images and sounds, fixed and moving images, leading the spectator into exploiting the images to find his own place in the landscape. By manipulating the Visorama, the spectator displaces himself ‘inside’ the projected image, exploiting it in its tiniest details. As from a 30× zoom, the spectator starts to perceive that the initial image is made up of small natural landscape images, which comprise another level of navigation. It is important to notice that the image keeps its resolution throughout the zoom selected whatever the navigation level. Upon penetrating one of these landscapes, the spectator becomes aware that the same process repeats itself, that is, it comprises a mosaic image with two depth levels in the former, the urban image is comprised of images with ‘natural’ scenery, in the latter, the ‘natural’ scenery is made up of faces. These faces display movement and talk about landscapes. The spectator perceives that these comments, which mingle with the sound of the landscapes previously seen (at the first and second level of navigation), are nothing more than the impression of the feelings of these persons into the landscapes that they lived in or imagined.

7.2 Visorama-Lumière installation

This is an interactive installation project in which Visorama is used for interacting with 360-degree panoramic photographs created between 1900 and 1904 by the Lumière Brothers with their *Périphote* camera (see figure 8). The panoramic photographs – in the cellulose nitrate format (8.7 cm x 62.8 cm) – are found in the CNC Archives. They had been made to be presented on Photorama, a system allowing for the projection of these panoramic pictures in a 20-metre diameter rotunda with an 8-metre high screen on the entire periphery. The goal of this project is the remaking of photographs of the places represented by the Lumière sights in order to allow the user to observe the transformations occurring to the landscapes represented, as well as to travel in space and time by way of Visorama. The user interacts with the photos of the past and present as if they were a virtual environment. The software component comprises a visualization system with a high-level language, allowing for the design of transition between the images and a multi-resolution module so as

Figure 8: Périphote Lumière.

to preserve the same image definition resolution during the zoom. These two characteristics of the visualization system allow for an immersion and greater interactivity of the environment represented through the photographs.

7.3 The Rear Window Project

Visorama integrates a group of contemporary mechanisms, halfway between audio-visual, art and interactive interfaces. In fact, in these last few years, we have watched the coming of a series of panoramic installations, contemporary to Visorama, whose mechanisms are also, in their own individual ways, a variation of the convergence of contemporary art, advanced technologies and cinema as new media. To make art converge in another way, with audio-visual and narrative interfaces, we radically transform the narrative possibilities of cinema. In the Rear Window Project, we use Visorama to reinvent the cinematographic experience of Hitchcock's film. The space of the Rear Window installation simulates the loft in the film by the same name. The idea is to force the interaction between the loft's real window and Visorama's virtual window. When the spectator manipulates the device, he produces certain events on the windows observed on buildings in sight. He can decide whether he wants to get closer to this or that window and, when he does so, he induces events. Certain events will transform the physical conditions of the loft where he is, mainly the lights, sounds, images on the television and the operation of certain devices such as the stereo and the clock. Everything is done so that the events triggered by the spectator surprise him, like in the movie.

8. Visorama as a cybernetic observatory

The Visorama may be featured also as a virtual museum for the creation of dynamic and interactive information spaces (see figure 9), a virtual window that allows us to visualize perceptive adventure in space and time. In order to understand the Visorama better, we shall analyse three examples of some changes currently taking place with the educational action of cultural centres, through the emergence of new communication technologies. The Visorama brings together, all at one time, these three features of the new museums as information spaces, by enlarging their spaces and actions, rendering their collection and experiences dynamic and, above all, by extending their networks.

1. The cultural spaces – libraries, museums, information centres, cultural centres – comprise the knots in a vast transformation network through which the world turns into information. The information that the cultural centres produce, transform, conserve and transmit, currently make part of our natural landscape and objects. However, a new intermediation strategy for the cultural network centres is being designed. The universal is not currently defined any more by concentration, but instead by connection.

   If the role of the communication of the cultural motivator, of the educator, changes, this specially changes the form of intermediation through which he or she performed so far: it is not any more a case of what all should know but building up a dynamic space in which the spectator will find his or her place. This change is akin to the one that took place during the shift from modern to contemporary art. In contemporary

Figure 9: The Visorama as a cybernetic observatory.

art, the work of art is open, that is, it does not pre-exist in relation to the spectator: it updates and defines itself only as from its relation to the spectator. The same situation should orient the information spaces of contemporary museums: the museum should present itself as an open space in which the spectator, in his or her own, individual manner, will find and construct his or her place.

2. Currently, the form for networking is crucial, not only for determining the cultural action in general, but in the assembling of a collection, of inventory knowledge. A collection is, as time passes, less the sum of its parts, and much more the relationship between the parts, the way in which the parts comprise a network. A museum, no matter how large it may be, always bears limitations of space. Currently, a museum may enormously increase its collection without necessarily having to enlarge its inventory. To such aim, the museum or cultural centre should be able to create articulations with the outside, so as to extend its nets.

   Combined with hypertext systems, digital technologies mean a new pedagogy and a new dynamics for the museological spaces. These allow for extending them considerably, as the hypertextual articulations comprise information spaces practically unlimited materially.

3. If we consider the book as a vehicle by which culture records, fixes and memorizes the ensemble of its knowledge, beliefs and visions, than we

> should agree that the audio-visual and multimedia products are also the books of our times.
>
> Just like the audio-visual and interactive interfaces, we have entered an era in which neither description linked to the language boundaries nor semantic games will be needed to communicate personal points of view, historical events or technical information. The direct and interactive demonstrations with the original materials then especially prevail, that is, we have, alongside of narrative and logics, simulations of virtual worlds and interactive information spaces.

Currently, with very little effort, we can acquire a virtual visit CD-ROM which enables us to move virtually through the space of a real museum like the Louvre, visit its collection, approach its objects, move around them, animate them, secure specialist information, contextualize them, in short, examine them in detail using multimedia resources.

The Visorama brings together, all at one time, these three features of the new museums as information spaces, by enlarging their spaces and actions, rendering their collection and experiences dynamic and, above all, by extending their networks.

The Visorama – as an immersive, but also as a panoramic image visualization system – descends from a technological lineage the history of which is unknown to most technical-image experts and that sends us back to the emergence of the panoramas. These images reproduce the view users would have if they were in the centre of the environment that is being simulated.

The spectator stays 'inside' an environment while the images are 'projected' around him. They always tend to realism in order to bring about in the spectator the sensation that the correspondent environment creates. The ways of interaction offered by the panoramic devices – *M*areoramas, Cineoramas, Photoramas, Sensoramas, Visoramas, etc. – are naturally accepted by the spectators for their likeness to the very way by which we are used to perceiving the world (as if we were in its centre). Here is, perhaps, the psychological explanation for the popularity of the panoramas and their variations.

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Mobile identities, technology and the socio-spatial relations of air travel

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Abstract

The remarkable growth in the application of information and communications technologies indicates a great shift toward a globally integrated society. The urban metropolises are turning into intersections of transit and migration of goods, capital, services, cultures, knowledge and especially people. Moreover the flow of bodies, information and money is changing the rules of what defines national territory, space and identity. Social realities with specific qualities are appearing, implying a new spatial correlation between the local and the global. International airports and within emerging extraterritorial zones have become an important threshold controlling the flow of people in a free market economy. The airport border mutates into an abstract space permeating the physical territory of the airport and beyond. This abstract border space, within which mobile bodies operate, is created by a bureaucratic system of inclusion and exclusion particular to transition states. Transit zones at airports emerge because of a complex set of factors: border crossing as well as increasingly stringent security and safety regulations. The innumerable thresholds within these transit zones are points of congestion governed and increasingly supported by technological systems of identification. Within the transnation state, the movement of bodies is the constant subject of streaming and proceduralization. Increasingly, the conventional system of control based on face-to-face interaction between the controlling and the controlled is being replaced by the algorithmic precision of database logic. The paradigm of 'pattern matching' ensures precise verification of the uniqueness of the body, in turn offering new potentials for permeability and flux. These different orders of legal and economic categorization create manifold sub-territories accessible to select groups of travellers. Nowadays, the airport is a transnation state spatialized through a new order of architecture, a manifestation of technology of abstract procedures of transition, inclusion and exclusion, adopting emergent patterns of socio-spatial mobility in a globalized network.

Keywords

socio-spatial mobilities
society and technology
surveillance
biometrics
cross-border circulation
deterritorialization

From 'kinetic elites' to 'frequent fliers'

In these times of constant mobility strongly influenced by the transformation of the world economy, metropolises are turning into intersections of transit and migration of goods, capital, services, cultures, knowledge and especially people. New concepts of urbanity with a transnational range are emerging. Moreover, the relationship between geographic and social space is shifting.

1. In the 1990s the philosopher Peter Sloterdijk described people who travel enormous amount of miles a year and use their home base primarily as a place to recuperate between flights, as 'Kinetic Elite'.

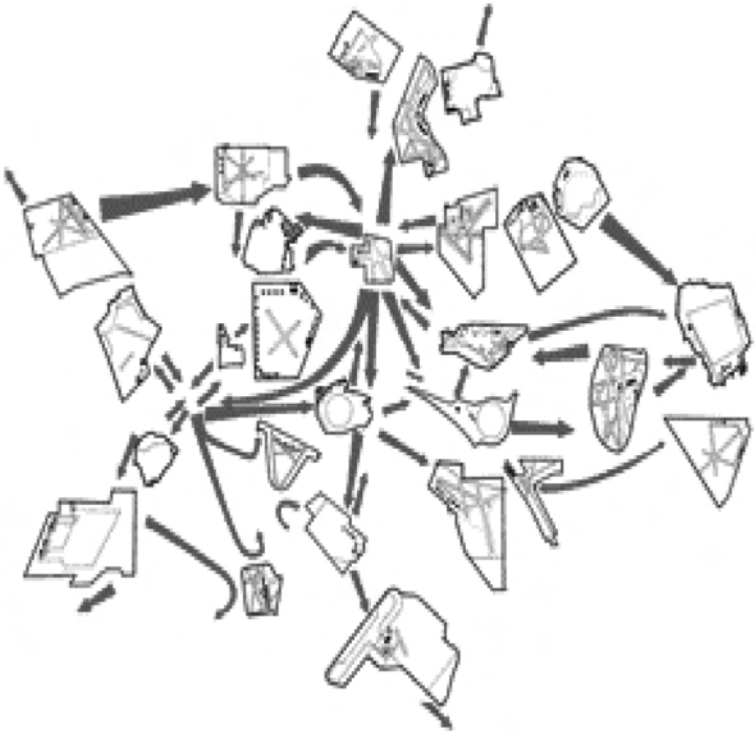

Figure 1: Terminal City, illustration of Geographies of Kinetic Elites © Monika Codourey, *re-make of* Naked City , *Guy Debord, 1957, with terminal hubs.*

Social realities with specific qualities are appearing beyond traditional descriptions of locality, implying new socio-spatial correlations between the local and the global. Martin Albrow describes these emerging socioscapes as a 'formation of co-existing social spheres, coeval and overlapping in space, but with fundamentally different horizons and time-spans' (Albrow 1997).

Today many global corporations take advantage of marketing, labour and other cost-saving measures by setting up their node-offices all over the world. This practice necessitates corporate representatives travelling regularly between various locations of a corporate empire. Mark Gottdeiner (2001) wrote:

> Many jobs are less dependent now on any one location than the use of many locations woven together as spaces for work using laptop, the cellular phone, the internet, or the fax. This mode of de-territorialization involves a progressively greater population and results in a redefinition of home, place, space and local community.

This nomadic lifestyle is increasingly dependant upon plane trips and international or even transnational activities. It is a lifestyle no longer practised solely by a highly mobile and affluent 'Kinetic Elite'.[1] Today almost all travellers are frequent fliers, using air transport the way people in the past used cars and trains for business and leisure.

Figure 2: Air travel elites: classification of frequent fliers.

The global market competition forces airlines to constantly lower their ticket prices. The growing variability of attractive flight offers allow 'event tourists' who are prepared to face cultural shock travelling on inexpensive flights to distant locations of the globe. The travel industry offers also endless opportunities to use western levels of comfort franchise facilities in exotic places for those who prefer avoid cultural shock, the 'package tourists'.

The traditional concepts of migration are being replaced by much more complex and dynamic mobility patterns of a transnational lifestyle. The new migrants, 'transnational travellers', often act as frequently flying agents between their country of origin and their new domicile. The less desirable part of flying elites are displaced persons, refugees or emigrants, the 'enforced cosmopolitans', who can afford pay a high price for the flight ticket (often their lifetime savings) in order to escape their miserable life circumstances.

The airport hub: aesthetics of socio-spatial mobility

The airport hubs, for example Frankfurt International Airport, are concentrations of local and global flows of information, people and goods in the world system. They act as a conduit from one physical location in the world to another and can be understood as compressors of space and time. The airport plays an important role in increasing cross-border circulation of frequently flying elites.

The airport hubs are transnational spaces inhabited by a mass of people travelling between nodes of a global network. Air travel is becoming increasingly inconvenient. Flights are often delayed, overbooked or cancelled. Crowded planes, cramped seating, poor meals and cabin service as well as the sheer boredom resulting from being stranded at terminals for hours are common to the point of cliché.

Different mobility patterns of varying relevance circulate in the airport's structure, and are distributed within airport architecture according to the typology of various levels of comfort and aesthetics. Growing business mobility has led to a segregation within business travellers according to miles spent in the air. For example, the division of lounges into Business, Senator, HON and First Class by Lufthansa exemplifies new strategies, priorities and standards in air travel based on flying status. These lounges not only offer different levels of comfort but as well various aesthetics. For example, Lufthansa is setting new international standards for their 'premium travellers,' who spend the most time in the air and generate 80 per cent of the airline's profit. Since December 2005, Lufthansa offers for 'preferred

Figure 3: The luxurious design of Lufthansa First Class terminal: terminal building, check-in area, waiting area, served snacks.

customers' a luxuriously styled separate HON/First Class terminal. To ensure the most comfortable and smoothest travel possible for their top clients, Lufthansa offers its services already on the ground in sophisticated architectural surroundings. The new dimension of travel with exclusive services and privileges includes parking a car to check-in, eased security control and customs, an exclusive ambience with gourmet catering, private rooms for work and refreshment, personal attention, a direct limousine transfer to the plane and even concierge services.

For those who do not participate in any airline bonus programme, 'pay-per-use' lounges such as 'Europe City Club' or 'Priority Club' offer exclusive airport spaces and services paid on an hourly basis.

Growing airline competition has led to budget optimization of the economy class. For example, cheaper tickets and lowering standards of service or even the opening of the low-cost Frankfurt Hahn Airport located 150 km away from Frankfurt city and linked by bus services with Frankfurt International Airport. Frankfurt-Hahn, a former US military base from the 1950s, became the first German low-cost airport to attain a 24-hour operating licence. Within only ten years Frankfurt-Hahn has become the tenth largest international airport in Germany providing services to all kind of travellers – including cost-conscious business people – from the whole world.

Displaced persons, refugees and immigrants are the unwanted part of the spatial segregation regime, within the airport space, in-between nation states. Shortly after the implementation of the 'Airport Procedure'[2] the new special purpose terminal building was built in the airport area physically detached from main terminal. This 'detention camp'[3] gives temporary accommodation to the refugees arriving by plane and prevents them from entering the territory of the nation. For enforced cosmopolitans with restricted legal rights, the comfort and airport services are reduced to the

2. The Airport Procedure is about establishing whether refugees get the right to apply for asylum in Germany. It lasts nineteen days. If a refugee gets sick in the camp and has to be brought to the hospital he still stays in transit. In the case of acceptance as an asylum seeker, the refugee will be brought to a asylum camp and will be subject to the asylum procedure. In the case of non-acceptance as an asylum seeker, the refugee is subject to the deportation procedure. If the person does not have any travel documents, there are two possibilities: first a voluntary stay in the detention camp until papers are available; or second, a move to the deportation jail and subject to proof procedure. If no passport is available after nine months the refugee has to be moved to the asylum

Figure 4: Reduced and price-conscious aesthetics of Frankfurt-Hahn: terminal building, interior, waiting room, airplane meal.

Figure 5: Realities of the detention camp: outside, inside, secured courtyard, living conditions.

absolute minimum. Asylum seekers are not allowed to leave the building during their stay at the privately secured detention camp. During their stay they are entitled to medical and social assistance. Social workers try to animate their stay at the camp offering various indoor and outdoor activities. Asylum seekers are carefully placed in the rooms according to their cultural similarities or places of origin. Refugees are not allowed to cook in the building because cultural differences could cause problems. Therefore airport catering services supply the meals. Asylum seekers are representatives of the middle and upper class of their countries of origin – those who can afford to pay for flight ticket. Accommodation at the camp is covered by the German government regulations for the time of the Airport Procedure. In case of any delay of their stay after the court decision the airlines bringing potential asylum seekers to the country are obliged to cover any further costs of this stay.

David Harvey (1990) wrote: 'We have been experiencing, these last two decades, an intense phase of time-space compression that has had a disorienting and disruptive impact upon political-economic practices, the balance of class power, as well upon cultural and social life.' At the airport different legal orders create a manifold series of sub-territories that are only accessible to a select group of travellers. The territory of 'frequent flyers' (lounges), a separate HON/First Class terminal for the 'kinetic elite', the distant low-cost Frankfurt-Hahn Airport for price-conscious tourists and business travellers, the secured territory of enforced cosmopolitans (the detention camp) are all examples of an emerging socio-spatial segregation at the airport.

Transit condition of the mobile body: locating the border at the Frankfurt Airport

The legally declared extraterritorial zone of the airport hub is a threshold controlling the flow of people in a free market economy. This space in-between exists outside the territorial limits of the nation. In fact, it is an abstract space created by a bureaucratic system of inclusion and exclusion within transnational states. Various laws, rules and agreements that apply to passengers, depending on nationality or travel status, regulate this zone. The International Air Agreement, Fundamental Rights (Asylum), the Geneva Refugee Convention, the Schengen Treaty and national border laws, airport security measures, the Sky Marshals Agreement, frequent flyer programmes, customs law, duty and tax free agreements or US security requirements are just a few examples of the growing list of airport rules and regulations.

camp but without change of status. He is still not accepted for the asylum procedure and can be deported as soon as travel documents are available.

3. The detention camp is also a part of the airport transit area. The number of asylum seekers has rapidly decreased since the implementation of the 'Airport Procedure' in 1993. Asylum seekers are not allowed to leave the building during their stay at the detention camp. They are not allowed to cook in the building because of cultural differences that could cause problems. Prepared meals are supplied by a catering service. Asylum seekers are carefully placed in the rooms according to their cultural similarities or places of origins. The airlines that are responsible for bringing potential asylum seekers to the country are obliged to cover the cost of accommodation in the camp.

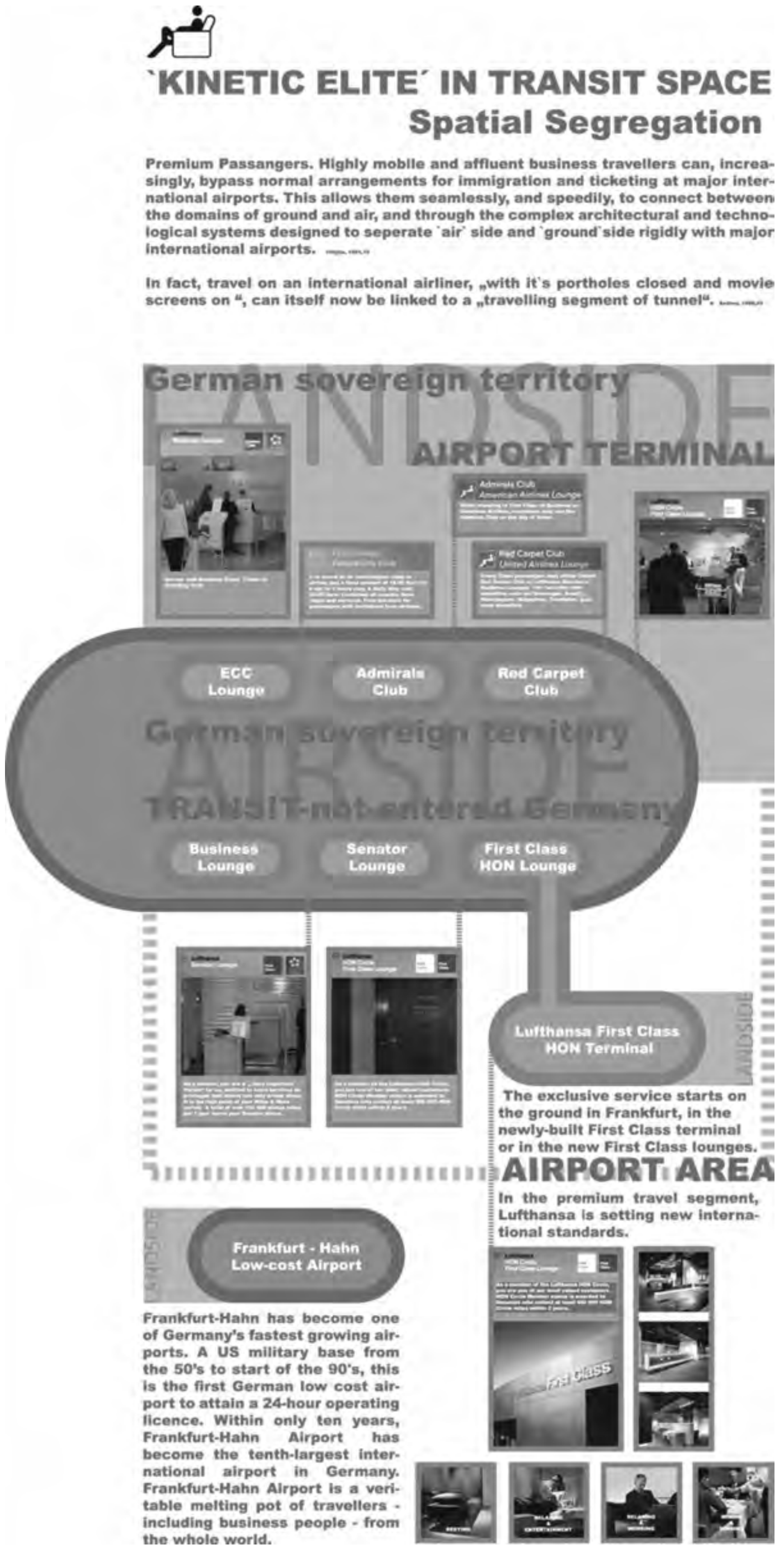

Figure 6: Airport spatial segregation: sub-territories of kinetic elites.

At the airport border the geo-political concept of nation state and the concept of global 'Empire' (Harvey 1990) modify the relationship between geographical and political space. The access to both is regulated by a very particular set of procedures and rules. The national border determines the geographical territory of a nation state and allows it to regulate an access to the country. At airports, the boundary of the nation is negotiated within an area inside the actual country. Moreover, the Frankfurt Airport border is not longer strictly national. With effect from 26 March 1995 the *Schengen Agreement* has been implemented in Europe. The aim of this agreement is to remove immigration control for travel within the collective territories of the member states. This creates a borderless region known as the Schengen territory. The Schengen countries introduced a common visa policy for the whole area and agreed to establish effective controls at its external borders. Checks at the internal borders may be carried out for a limited period if public order or national security make this necessary. On the one hand this space promises to overcome the violent legacies of the nation state, while at the very same time undergoes a process of effective border fortification and cultural homogenization. Moreover, increasingly the border condition turns into a space itself: the airport's so-called *transit area or air side*[4] is in fact an jurisdictional enclave inside the territorial boundaries of a nation. Various laws, rules and agreements that apply to passengers, depending on nationality or travel status, regulate this zone.

What is more, in many cases the area of jurisdictional exclusion extends beyond the physical territory of airports. This makes it impossible to mark this artificial boundary at the footprint of the airport. In fact it does not make any difference where the border is located. The checks can be activated at any time within the airport transit zone depending on the situation. For example, as long as the doors of the airplane are opened, the space of the airport is an extension of the transit zone.

Another good example of the detachment between physical and social space practices is the implementation of the Airport Procedure. The Airport Procedure is about establishing whether refugees get the right to apply for asylum in Germany before legally entering the country. During nineteen-day procedure asylum seekers are not allowed to leave the building during their stay at the *air side* of the airport in a specially designated detention camp. In case of refusal to voluntarily stay in the detention camp the refugee is transferred directly to a deportation jail and subject to the so-called Proof Procedure. In both cases the asylum seekers are residing in the geographical territory of the country, they are not entitled to the so-called 'entered Germany' status even if they have to be transported to the hospital or asylum camp, and are still subject to immediate deportation. Since the implementation of the Airport Procedure the statistical number of asylum seekers has rapidly decreased because it is almost impossible to cross the German border in the legal sense.

The airport border is not a simple line separating geographic regions or political divisions anymore. According to Balibar the borders are not disappearing, they are intensifying and being both 'multiplied and reduced in their localization and their function, thinned and doubled, even becoming zones, regions and countries where people are forced to reside and live' (Balibar 1995). Nowadays, rather than a geographical boundary of the state, the airport borders are a transit condition of the mobile body.

4. Justine Lloyd points out that, 'The discursive basis of this border is clear in the history of the term "air side". The demarcation of a new form of border through this legal and administrative term – first used during the 1950s – clearly describes that part of the global city which is not considered national territory for the purposes of immigration and customs control' (Lloyd (2002).

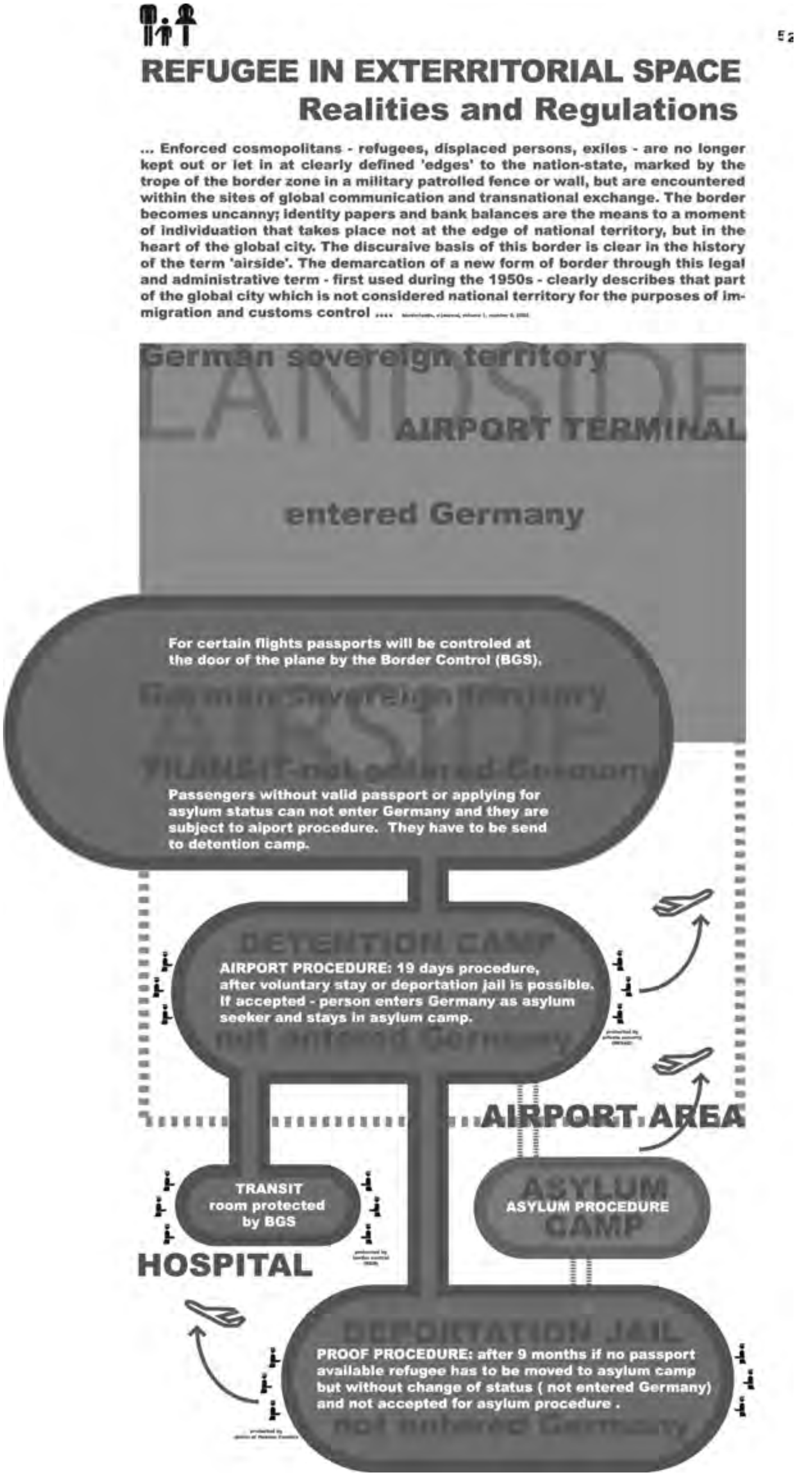

Figure 7: Legal extension of exterritorial zone outside airport area for enforced cosmopolitans.

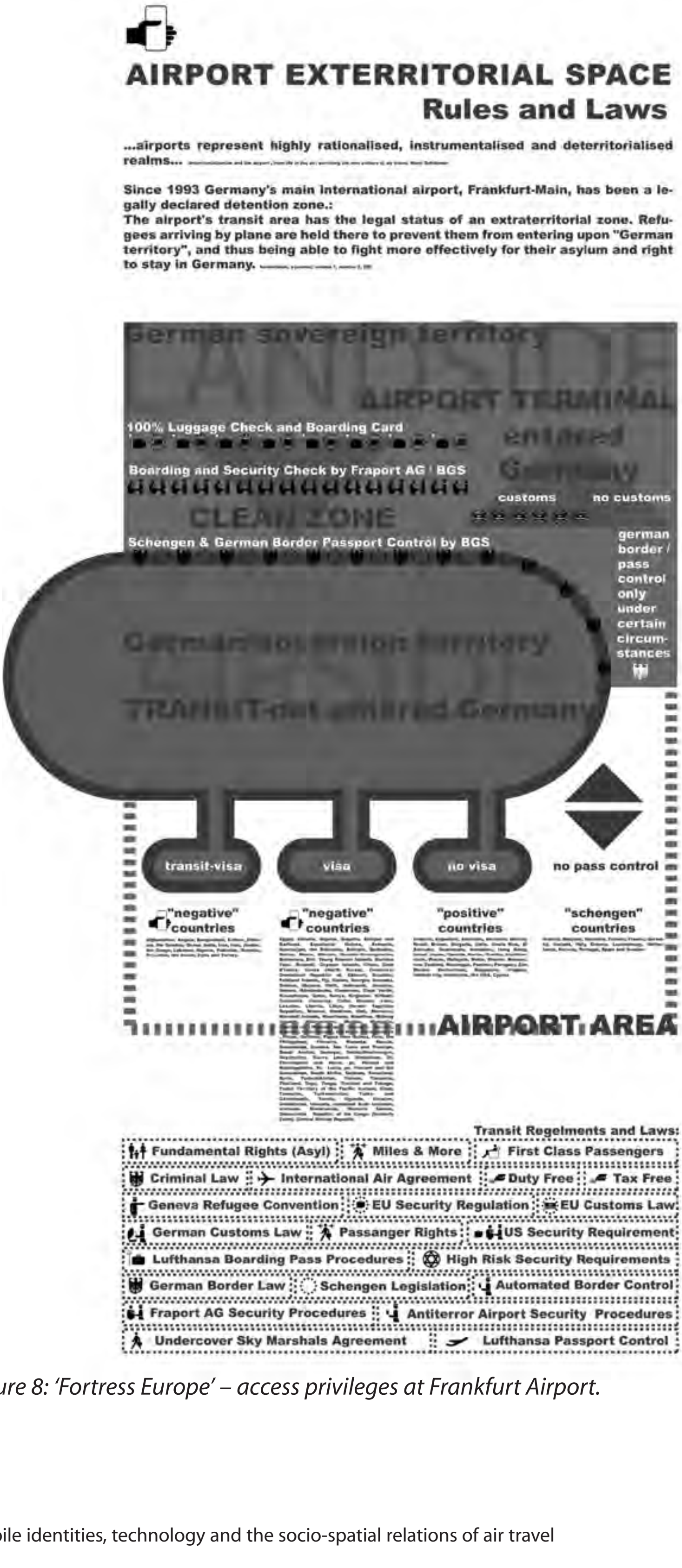

Figure 8: 'Fortress Europe' – access privileges at Frankfurt Airport.

Airport threshold: technology of space and body in transit

Transit zones at airports emerge because of a complex set of factors: as a border crossing as well as contemporary security and safety regulations. The innumerable thresholds to the transit zones are points of congestion that are governed by an imperfect system of identification. Gillian Fuller writes: 'The airport constitutes a space where a series of contractual declarations: I am Australian, I have nothing to declare, I packed my bags myself, accumulate into a password where I am free to deterritorialise on a literal level – I take flight, but not without a "cost". I have been scanned, checked and made to feel guilty' (Fuller 2003).

Different mobility patterns of varying relevance circulate in the airport's structure, and they are distributed within the airport architecture according to the typology of various levels of comfort and aesthetics. Travellers move through airport safety and security thresholds at different speeds. The economy-class travellers must take into account longer check-in procedures than privileged business and first-class travellers. Paul Viriglio observed that:

> Highly mobile and affluent business travellers can, increasingly, bypass normal arrangements for immigration and ticketing at major international airports. This allows them seamlessly, and speedily, to connect between the domains of ground and air, and through the complex architectural and technological systems designed to separate 'air' side and 'ground' side rigidly with major international airports
>
> (Virilio 1991).

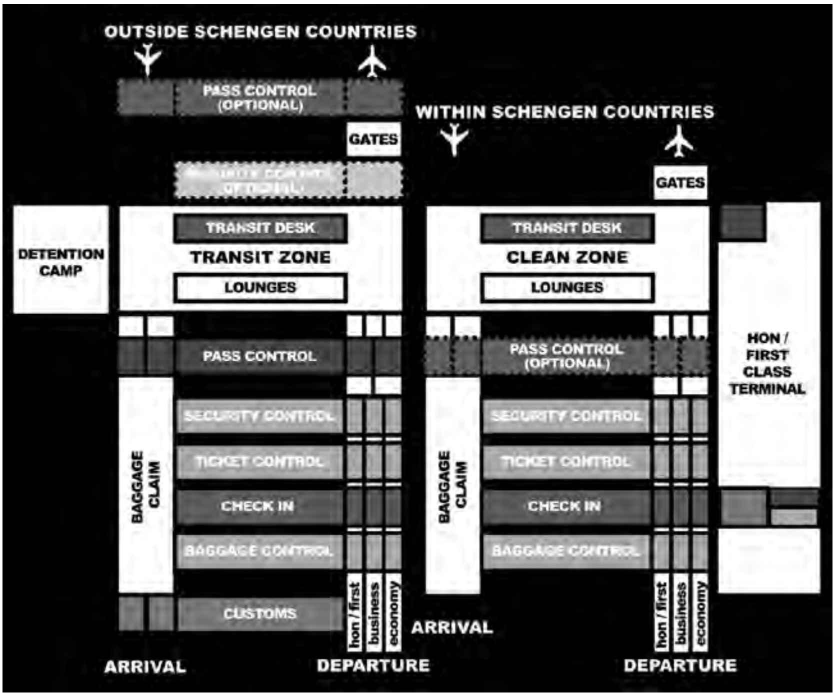

Figure 9: 'Tunnelling effect' at airport thresholds.

Figure 10: Check-in points for economy, HON/first class and quick check-in terminal.

At the airport, travellers move through different spaces, and their commodified movements are constantly streamlined and proceduralized. In point-to-point airport traffic, technology plays an increasingly important role. Metal detectors, machines to X-ray luggage, quick check-in and other facilities are already a vital part of transnational spaces of control and security. Recently, in order to guarantee the highest degree of security possible, airports have been using the latest technology in automated border control. It replaces face-to-face (F2F) interaction between the controlled and those who control. The newest technology is based on biometrics and allows fast and convenient self-service border checks.[5] It grants entitled travellers unrestricted freedom of movement. This method also allows authorities to be more efficient and accurate when identifying people at airport border crossings.

The biometric system of authentication ties access codes to the bodies of travellers. Mobile individuals no longer have to be identified as a whole. The 'pattern match', the algorithmic logic of a database, replaces characteristics of the individual in a biometric system of control, inclusion and exclusion. Because they measure and statistically analyse the body as biological data, *biometrics*[6] is the perfect match for permeable borders, ensuring the verification of the uniqueness of every body.[7]

Increasingly, the conventional system of control, inclusion and exclusion based on face-to-face interaction between the controlling and the controlled will be replaced by the algorithmic logic of databases. The 'pattern match' ensures the verification of the uniqueness of the body and makes the airport border permeable.

5. 'Fast and convenient – in the future you can handle border checks yourself. If you don't feel like waiting in line at the border control point, you can use the new automatic border control lanes at Frankfurt Airport. Until now passengers on non-Schengen flights were checked by border control officers each time they entered Germany. This manual check often included long waiting lines [. . .] Participation is voluntary, however, only citizens from the EU/EEC countries and Switzerland entitled to unrestricted freedom of movement who are 18 years or older and hold a machine-readable passport may participate.' (Source: BGS flyer: *Automated Border Control. Do you want to participate?*
6. Biometrics is the science and technology

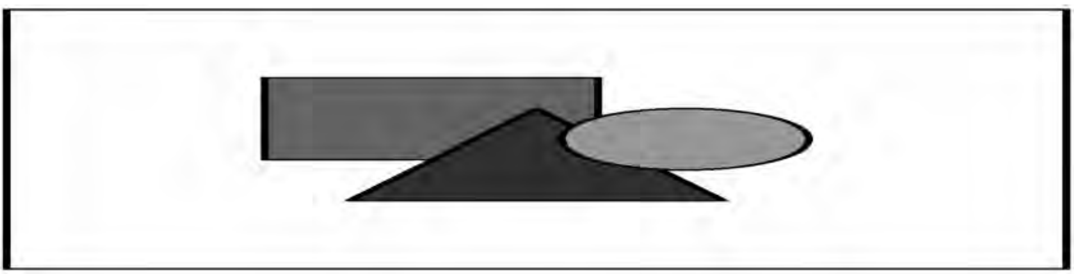

Figure 11: Border crossing for economy, HON/first class and 'smart border'.

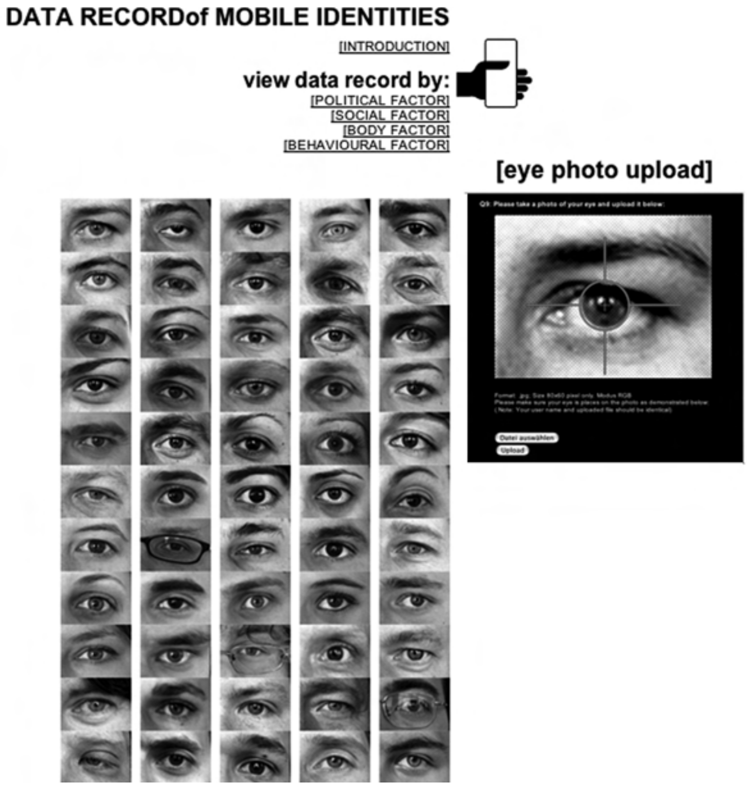

Figure 12: Uniqueness of everybody in installation: Data Record of Mobile Identities. *http://www.mobile-identities.info*

In this system of relevance the body must be captured, coded and scanned. Therefore mobile individuals are increasingly integrated into a collective electronic database;[8] a collection of data arranged for easy and speedy search and retrieval. Transnational spaces of airports continue to face different patterns of mobility that are also concerned with the biometric pattern match. In the near future,[9] anyone who resists submitting his or her body pattern into a global network of tracking and control will simply not gain access to the transit zone, a space of flow of network society.

Nowadays, the airport is more than just a mixture of complex infrastructures and the emergence of city-like functions. It has become a transnational state of mobility. Nowadays airports are a manifestation of technology of abstract procedures of transition, inclusion and exclusion and emergent patterns of socio-spatial mobility in the global network.

The field research was done at the Frankfurt Main Airport, and it is largely based on interviews with border control officials (BGS and ZOLL), Fraport AG, Lufthansa and Caritas employees. The results of the research were points of departure for the creation of maps of the diverse transit conditions of air travellers and served as the basis for production of the video devoted to the subject. The analysis of spatial reorganization of the airport was the basis for a media installation, Data Record of Mobile Identities*, initiated in cooperation with Bauhaus Dessau Foundation, Germany.*

of authentification by measuring the person's physiological or behavioural features. The term is derived from the Greek words 'bios' for life and 'metron' for measure. In a typical IT biometric system, a person registers with the system when one or more of his physiological characteristics are obtained, processed by a numerical algorithm, and entered into a database. Ideally, when he logs in, all of his features in the technology, 'match 100%; then when someone else tries to log in, she does not fully match, so the system will not allow her to log in. Current technologies have widely varying Equal Error Rates – as low as 60% and as high as 99.9%. http://www.ikonengineering.com/security_services.asp Accessed 9 January 2008.

7. The objective of the project is to create a database of mobile identities that is open to everyone, and draw attention to issues pertaining to the classification of mobile subjects. The project interface allows for the scanning of photos of eyes into a databank. Persons participating in the project were asked to fill out a 'Five-minute Travel Form'. The travel form asks for information on, for example, travellers' mobility patterns, their perception of the airport space and their particular experience with or emotions about airport border controls. Installation: *Data Records of Mobile Identities*, http://www.mobile-identities.info

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Accessed 9 January 2008.

8. 'International migration affects the development of information technology,' Reynold Koslowski has said. Such new technology includes databases that will screen visitors, new border controls, advanced information on passengers and cargo, and an entry-exit system that could track visas and trace visa overstays. See Koslowsky's article, 'Travel and Migration Borders on New Technology', at http://www.wilsoncenter.org/index.cfm?fuseaction=news.item&news_id=53546. Accessed 9 January 2008.

9. According to a White House statement (2002):

   'The border of the future must integrate actions abroad to screen goods and people prior to their arrival in sovereign US territory, and inspections at the border and measures within the United States to ensure compliance with entry and import permits [. . .] Agreements with our neighbors, major trading partners, and private industry will allow extensive pre-screening of low-risk traffic, thereby allowing limited assets to focus attention on high-risk traffic. The use of advanced technology to track the movement of cargo and the entry and exit of individuals is essential to the task of managing the movement of hundreds of millions of individuals, conveyances, and vehicles.'

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