Testing the Space of the Virtual

Brian Lonsway, Informatics and Architecture, Rensselaer Polytechnic Institute, USA

Abstract

Various modes of electronically mediated communication, perception, and immersive bodily engagement, generally categorized as "virtual experiences," have offered the designer of space a new array of spatial conditions to address. Each of these modes of virtual experience, from text-based discussion forums to immersive virtual reality environments, presents challenges to traditional assumptions about space and its inhabitation. These challenges require design theorization which extends beyond the notions of design within the electronic space (the textual description of the chat forum, the appearance of the computer generated imagery, etc.), and require a reconsideration of the entire electronic and physical apparatus of the mediating devices (the physical spaces which facilitate the interaction, the manner of their connection to the virtual spaces, etc.). In light of the lack of spatial theorization in this area, this paper presents both an experimental framework for understanding this complete space of the virtual and outlines a current research project addressing these theoretical challenges through the spatial implementation of a synthetic environment.

1 Proposition

Like most binary oppositions, that formulated between virtual reality (VR) and real life (RL) does little to advance our understanding of the complex spatial and cultural implications of new immersive technologies. If we, as designers, are to competently address the systemic shifts that may or may not be induced by these technologies, it is imperative that we have the capacity to understand their explicit and implicit modes of operation. And in particular, as designers generally concerned with the manipulation of space, we should have the capacity to understand the way in which they operate *spatially*. The commonly accepted but reductive framework, which categorically separates the space of the virtual experience from our larger spatial context, privileges technological apparatus over socio-spatial context, perception, and inhabitation. This attitude is echoed in most cultural representations of VR: product advertising promotes the ability of users to leave their real environments and enter fantastic ones with the aid of certain devices, developmental research of VR systems focuses almost entirely on technical implementation and discusses social or psychological issues only where these are a result of technological development, and popular fiction invents myriad mechanisms and devices which provide novel ways to travel *from* "RL" *into* cyberspace. Not all research in VR technologies, of course, so naively fails to recognize the significant amount of interconnectedness between the "virtual" part of the experience and that part not conceptualized as such (the existence of the body, the physical manifestation of the technological apparatus, etc.).[1] However, even a perfunctory analysis of VR research concerned with spatial implications reveals that the opposition between the *real* and the *virtual* has become quite instrumentalized. The commonly accepted space of VR is that representation of space, which is presented perceptually *to* the user. This conceptualization of space privileges, through technological capability, the representational aspects of space – the conception of space as a geometric (and due to dominant representational systems, Cartesian) realm accommodating placement, movement, and proximity. This geometrically instrumentalized conception of space fails to recognize space's material or social aspects, and therefore excludes the space of immersive operation (i.e., that space within which the VR experience takes place). I would like to argue for an expansion of this narrow spatial conceptualization as a way of transcending the merely technological manner in which VR technologies are currently being developed. This expanded notion positions the space of the VR experience as a mediated (specifically, "informated") realm, which includes not only the domain of representation, but the

physical domain of the apparatus and the physical and psychological domain of those who interact with it. Through this reformulation, the domain of VR design and implementation must become productively engaged with the domain of human social experience.

I would like to borrow a term that has been used to conceptualize the realm of human interactions with technology as a socially engaged phenomenon: virtuality. Margaret Morse, in particular, has embraced this notion in her book of the same name to examine a wide range of technological and spatial constructs, which are highly relevant to the discussion at hand (Morse, 1998). Morse explains virtualities by tracing elements of Heideggerian phenomenology through the viewpoint of a contemporary cultural anthropologist: "cultural forms from television graphics and shopping malls to the apparatus of virtual reality, as well as practices from driving to conducting war to making art employ various forms of engagement to construct a *virtual relationship* between subjects in a here-and-now." She later suggests "monitor-human relations are thus bubbles or pockets of virtuality in the midst of the material world." By generalizing the notion of a virtuality to include all conditions of *in-effect-but-not-in-fact*, Morse is able to contextualize the concept of VR and virtual experiences within a social framework. Morse begins her argument with an analysis of the subjectivity-constructing effects of television. The television, she argues, continually positions its viewers as a "you" through the single-sided dissemination of information. The act of broadcasting, most apparently in news and advertising, although equally at play in all configurations of market-directed programming, is an act of subjectivity construction through the emphasis of the "you," the receiver of televisual utterances. Advertisements speak to a valued consumer and are placed during programs that have been proven to be popular with specific demographic groups. Their transmissions are directed to "you" as "you" are supposed to be. Viewers form subjective representations of their selves through the identification of themselves as this "you," even if, as Morse suggests, the "you may not actually be in that position," having flipped channels, left the room, or otherwise broken the dissemination. This temporal "you" as a subject of televisual utterance exists as a kind of virtuality: a realm that appears in effect, although not in actual fact. On one hand, you are still the you you were before the utterance, but you are also now the "you" who should buy detergent, tune in later, wear particular clothing, etc.; effectively, your subjectivity has multiplied. Furthermore, with regard to interactive experiences, Morse argues that there has been a shift from the subjectivity discourse of the "you" to the subjectivity discourse of the "I," where technological interaction is used to construct an "I" which, similar to the "you" of television, is located in a particular space and time. With the special case of the immersive VR experience, the user is (in actual fact) located in physical space within the apparatus of the technology. The computer-mediated environment suggests (in effect) a trans-location outside of this domain, but only through the construction of a subject centered on the self ("I"), controlling an abstract position in a graphic database of spatial coordinates. The individual, of which this newly positioned subject is but one component, is participant in a virtuality: a spatio-temporal moment of immersion, virtualized travel, physical fixity, and perhaps, depending on the technologies employed, electro-magnetic frequency exposure, lag-time nausea, etc.

This is hardly a new concept; similar notions of subjectivity formation that have evolved from Lacanian psychoanalysis proliferate in late 20th century cultural theory. What is potent about Morse's observation, however, is the way in which she commodifies the term virtuality to refer to this moment of subjective multiplicity as a moment of technological engagement.[2] If the notion of virtuality is expanded to include any moment of such multiplied identification or subjectivity formation, then the virtuality becomes a way of conceptualizing these mediated moments of subjectivity identification. There is, by this argument, no substantial distinction between the mediation of our perception by VR apparatuses and by our genetic, cultural, physical, or other technological mediations. All such mediations, technologically manifest or not, form our senses of reality and subjective positions within it. VR, therein, is merely another one of these moments, taking place in the space of our lives. It's space is not, therefore, the instrumentalized space of its presentation devices, but the subjectivity-forming space of its physical, cultural, and social manifestation. The understanding of so-called VR experiences as virtualities rather than technologized events in which a virtual experience takes place suggests that the latter fails to recognize the larger context of such interactions or events, and places complete faith in a technological system to address the complexities of human social experience. These technologically determinate models, I argue, are unable to account for complex social and human behavioral conditions not because of technological limitations, but because of the restrictive means of conceptualizing the very nature of such environments

Primary among the existing models of understanding the design and development of virtual systems is that of *presence*. (Barfield, Zeltzer, Sheridan, Slater, 1995; Schloerb, 1995; Darken, Allard, Achille, 1998) This metric evaluates the success of a virtual environment system as a measure of an individual user's sense of feeling present in the simulated environment. While clearly rooted in the proprioceptive reactions of the user, this means of measure is biased toward the matter of technological facilitation rather than spatial or social engagement with the facilitated environment. The evaluative question basically asks "does the technology of the virtual system interfere in any way with your ability to believe that you are located in a space different than the one your body is in?" The technical literature concerning presence enumerates those things which obstruct or hinder its perception, including obstructive aspects of gear, lag time in image updating, lack of realism in visual, aural, or tactile presentation, or lack of a complete multi-sensory environment. Philosophically, I find it somewhat untenable to evaluate the concept of presence without first establishing a measure of the socio-spatial context within which presence is measured. In particular, I see three significant problems inherent in this assumption. First, the measure of presence in a virtual environment above all assumes that the sensation of presence is a natural means of human interaction with and perception of our social and physical environments. This privileges the already-present or assumed present within a given cultural context. N. Katherine Hayles and Alluquere Stone among others have written extensively on the cultured associations of such assumptions, arguing that the privileging of that which is present merely privileges predominant cultural types: the male, the "normal," etc. (Hayles 1999; Stone 1995). Successful presence, of course, privileges certain abilities: the ability to afford (financially or temporally) to interact with a VR environment, the knowledge of how to navigate, the level of comfort with the cultural environments represented (often warlike or gender-biased), the lack of fear of technology (in particular when it has to be worn or applied to the body). Those without these abilities are, by the VR industry's measure of presence, already absent. Second, aside from these social and psychological problems, it has not yet been established that those of us who are considered present by this measure exist capably in the world by measuring our successful interaction with our surroundings via the question "do I feel present here?". An empirical assumption derived from early existentialist thought, this belief fails to address a myriad of other possible models for spatial interaction that extend beyond the primarily visceral and psychological concept of spatial interaction and into the socio-cultural. And finally, there is an irony in even conceptualizing the need to have such a measure as presence. If we take a less technologically mediated condition of virtual existence – immersion in the plot of a printed book – it is impossible to conceive of one's immersion in the book and one's spatial immersion in a physical environment independently. With the imperative to sensorially immerse a participant completely in another realm with advanced technologies, however, the problem of the electronic replacement of the physical comes to the fore. The technology draws a distinction between the technologically mediated and the non-technological. The immersive technology of virtual environments, a direct manifestation of the philosophical underpinning of VR research, itself raises the problem of presence.

In addressing these limitations of the presence model for evaluating virtual environments, I find Morse's notion of the virtuality to be most instructive.[3] If the moment of interaction with the virtual environment is conceived to be akin to the moment of interaction with a television or a telephone, then we can more easily see how this immersion is no different than any technological engagement. The engagement is an event of mediated socialization (socially and spatially *immersive*) rather than technologized escape from the everyday (socially and spatially *divisive*). The space of this engagement is multi-scalar, encompassing the space of computer-assisted vision as well as the space of subjectivity inducement and the space of cultural association. But what is, in fact, the space of the virtuality, and how specifically is the theorization of this space different than that within existing conceptualizations of virtual space or cyberspace?

To best answer this, in particular as theorization in this specific area of exploration is limited, I would like to offer three independent digressions which collude in a revealing way with respect to this line of thought: one each into phenomenology, cultural geography, and post-structuralism. I offer these as observations towards an experimental theorization of virtuality, as I have only begun to explore the practical implications of this theoretical framing. The entry of these digressions into my own work was via radically distinct paths, but the network of ideas they represent is highly provocative to the exploration at hand. Most importantly, they have proven essential as foundations for our applied work in the implementation of the Synthetic Space Environment (SSE) at Rensselaer's

Informatics and Architecture program. After these digressions, I will provide an introduction to our current development of this spatial environment, which is an attempt to reexamine "VR" as a virtuality. This will also serve to elucidate the more arcane notions of space, subjectivity, and virtuality, which have just been, or are about to be, presented.

2 Digression 1: Being

Martin Heidegger bases his phenomenology on a philosophical inquiry into a set of concepts considered essential to human existence, and which he argues lie underneath our more readily understandable social concepts like body, space, and time. These essential or primordial concepts are rooted specifically in the notion of our being. It seems irresistible to link the technical exploration of presence in VR environments with Heidegger's *being*, as the act of being present is one of his own philosophical foundations for his notion of *being-in-the-world*. Heidegger classifies these essential concepts as what we would now call second-order classifications via terms like "embodiment" and "spatiality." Hierarchical relationships are set up between these concepts and their primary referents (spatiality is an essential concept for the recognizance of space, embodiment for body, etc.) I find it difficult not to see *virtuality* within this system of fundamental concepts, even though Heidegger's hierarchical and essentializing theorization is quite remote from Margaret Morse's (and my own) theoretical positions. Nevertheless, by framing the virtuality as a kind of essential concept which precedes the virtual, and which constitutes the level of engagement of the phenomenal being-in-the-world (presence), we find support for the understanding of presence not as a measure of virtuality; but as a result of it. Rather than postulate the examination of presence within a context of technological facilitation, as do current writers on virtual systems, we can make the argument that presence has as its core the entire, experienced spatial system (spatiality) within which this technology is situated, the entire construct of the physical body (embodiment) which is used to engage the technology, and the entire system of technologically mediated subjectivity (virtuality). In order to measure presence, in other words, it is not acceptable to merely inquire of VR experiment participants how present they might have felt. What is required is that these participants be given the opportunity creatively, subjectively, and personally to establish their own sense of embodiment, to understand their spatiality, and to conceptualize their virtuality.

3 Digression 2: Space

The understanding of space is part of a long philosophical tradition, and my brief analysis here is no attempt to categorize this history or even to succinctly address its significant moments. This is not even an attempt to offer any kind of totalizing conception of space. It is an attempt, nevertheless, to position a multiscalar reading of the modes of spatial operation, which we seem to most regularly encounter implicitly or explicitly in our contemporary actions and discourses. Much of this outline is grounded in the post-Marxist tradition of writing on space in the last three decades, notably that of Henri Lefebvre, Michel Foucault, Manuel Castells, and Edward Soja (Lefebvre, 1974; Foucault, 1970; Castells, 1989; Soja, 1989). Fundamentally, actions and discourses form an array of operations that constitute three scales of spatial practices: the Cartesian, the landscaped, and the organizational. Cartesian spatial practices are formed from essentially geometric readings of space; consisting entirely of quantitative spatial relationships, spatial activity is limited to location, extension, and proximity. Movement is implicitly addressed but not facilitated (i.e., vectors and curves can be constructed within a Cartesian system, but the rules of Cartesian ordering do not provide the tools to construct them). The landscaped (or landscopic) mode of spatial practice introduces a social arena that is produced or constructed in certain arrangements to facilitate cultural sustenance or human desire. Where the Cartesian framing of space introduces location, distance, and direction as spatial operatives, the landscopic introduces inhabitation, navigation, and movement (Zukin, 1991). One can speak of a landscape of power, or an urban or suburban landscape, or a landscape of thoughts. Spatially, the landscape is a framing device, collecting diverse and discrete phenomena into a collective realm of social interaction. And finally, the organizational practice of space extends the spatial into the tropic realm of conceptualization. Here, the metaphors of Cartesian and landscopic spatial practices are used to form spatial domains for any phenomena that could benefit from the vocabulary of spatial relationships. When we speak of navigating the World Wide Web, or refer to the proximity of one piece of information to another, we are spatializing these phenomena through our rhetorical modes of operation.

It is the entire complex of these three modes of spatial operation that I take as the foundation for exploring the virtuality. Typical models of virtual systems base any notions of spatiality (via measures of presence) on only a Cartesian definition, limiting social and metaphorical applications of

the broader framework of space to quantifiable phenomena: the establishment of *wayfinding*, the determination of participant location, the tracking of user orientation, etc.[4] Socially, however, we always operate in all three spatial modes (and perhaps others) in the spatial engagement of our everyday lives. The fluidity of space allows us or even requires us to shift modes of occupation invisibly, to engage multiple models at once, or even form our own transitory models to contend with particularities. And likewise, as our interactions with the machinery of the virtual are participant in our common lived space, we must fluidly engage these spatial modes of operation when interacting or performing within the virtuality.

Edward Soja, in his highly influential *Postmodern Geographies*, explores the role of space within Marxist and post-Marxist critical social theory, and attempts to engender a critical investigation of spatial practices as fundamental to contemporary processes of capitalist development (Soja, 1989). Explicit in his work is a critique of the failure of much contemporary social theory to recognize the spatial practices at work in socio-economic development. Soja recognizes the need to couple this critique with certain ontological investigations of *spatiality* as a component of his reassertion of space as a political project. Briefly examining Marxist and Giddensian economics, and Sartre's and Heidegger's phenomenology, Soja presents two moments of "misplaced spatiality:" the illusion of opacity present in materialist thought failing to recognize the social aspects of space because of obsessions with objects-in-space, and the illusion of transparency present in existential phenomenology which fails to recognize space as a physical and material phenomenon. The illusion of opacity is fundamentally a restatement of my critique of the technologically determinist model; the illusion of transparency is a critique of the essentializing problem of Heidegger's theorization of spatiality. Spatiality for Soja operates fluidly across material and mental realms, serving as much as a result of material processes as an intangible conceptualization of social processes. If we insert this notion of spatiality into Heidegger's model of presence, we more clearly see how popular measures of presence (the understanding of presence as a measure rather than a result) fail to address the spatial complexity inherent in a virtual experience. But in what manner is this failure realized, and why do these myopic investigations of a representational spatiality dominate technical explorations of virtual reality?

4 Digression 3: Myth

I have suggested earlier how the rhetoric embedded within technological implementation privileges the popularly divisive manner of understanding the space of the virtuality as an opposition of the virtual to the real. To more clearly understand the principles at work in this rhetorical system, I would like to turn to Roland Barthes' articulation of a cultural construction he calls *myth*.[5] This notion of myth is devised to explain a new cultural form of communication that, for Barthes, has replaced the traditional forms of ideological discourse. Unlike the manifestations of the latter, which form clear statements of unmasked intentionality, mythological articulations are constructed from careful manipulations of semiotic structure so as to defer their ideological intentionality and to present instead their distortions as truth. For the ideological, what is said is important; for the mythological, how one says what is said is important. This latter fashion of communication dominates our cultural landscape, where substitutions of significance replace meanings through associative presentation. When we see an advertisement for toothpaste which shows images of happy couples in love, the myth is operating to equate happiness in life with oral hygiene; the ideological intention is to support the pharmaceutical industry through toothpaste purchases, but this message is deferred through its carefully manipulated representation. This mythical practice extends through all areas of communication, including that of technological validation. In the same way that Soja feels a need to reassert the importance of space in the critical practices of cultural production, I feel that there is a need to reassert its presence in the domain of technological production. The cultural myth of high technology operates to sustain its self-importance at all costs. Practices that engage such technology are frequently absorbed into its mythical self-sustenance, becoming a proponent of the technology itself. This is certainly true in the development of virtual reality technologies, where their rhetorical and practiced fetishization subsumes critical discourse positioned outside of the technological system. It doesn't even make such sense at first, for example, to speak of the non-technological components of virtual reality: the very way that we understand VR is grounded in the technology that facilitates it. Thus, the myth stipulates that the virtual is *only* that which exists inside of, or because of the VR gear; the spatial is *only* that representation of space that exists on screen; the *present* is only (ironically) a state of escape, etc. Only technological research is validated as VR research; critical analyses are (merely) cultural theory.

5 Implementation

Addressing this technological obsession returns me once again to the virtuality, and to a need to creatively explore the implications of these digressions and the theoretical framework in which I have placed them. Understanding the virtuality – a socio-spatial construct that includes, but does not privilege the technologically mediated experience of engagement with a specific set of interactive devices – requires that its tenants be tested in practice. I have, within the Informatics and Architecture program at Rensselaer Polytechnic Institute, begun this testing through the implementation of a unique type of computer-mediated spatial environment, the Synthetic Space Environment. This environment has been framed from its conceptualization as a spatial enterprise that accounts for the theoretical complexity I have introduced in this paper. Our research specifically attempts to engage the development and implementation of a synthetic reality environment[6] on socio-spatial terms (i.e., as a virtuality), and argues that this means of conceptualizing the domain of virtual reality environments may more substantially address current limitations of VR research than typical technology-focused means. Through this broader spatial framework, problems which are typically seen as purely technical (rendering speed, tracking accuracy, ergonomic design of worn equipment, etc.) become problems which may be addressed through a variety of spatial mechanisms.

Our current work has involved the creation of a real-time network-based synthetic environment, which has addressed the spatial complexities called for above through the simultaneous pursuit of technical development, design, and evaluation. The project calls for a multi-sited venue for the collaborative teaching of architectural design based on existing studio-based models of design teaching. For this reason, it is important that user obstruction by head-mounted displays, tracking devices, etc. be eliminated, and that the spatial mode of user interaction be highly intuitive, and at as close to full-scale as is possible. From our theoretical interests, we also wanted to avoid any qualitative predeterminations about what is and is not virtual, and to put into question the fundamental separation of real and virtual spaces which existing technologies reify. For these reasons, we chose to work with a derivation of virtual set or virtual studio technologies, which use chroma-key technologies to visually and aurally compose participants into computer-generated or video-based environments. Interactions among users in the space and between users and the computer-generated environment occur in the physical space of the user at full scale. By using this kind of technology, therefore, we were immediately able to both eliminate the need for head-mounted displays and to work at the full scale of the users' physical surroundings. Again because we did not categorize any spatial condition as either *real* or *virtual*, we were able to opportune ourselves of a technological artifact of virtual set systems to expand the space of user interaction. A typical virtual reality system is concerned primarily with the eradication of the physical environment so that its user may have a greater sense of presence in the virtual environment. Even augmented reality systems, which superimpose computer-generated overlays onto a user's physical environment via transparent head-mounted displays, limit the augmented spatial interaction of a user to objects that have been previously coded into the system. Each of these systems relies on the spatial division of the real and the virtual, as they require an active insertion of one into the other in order to operate. Virtual set systems, on the other hand, expand space in their technical operation, composing the environment of the user's bodies with the computer-generated environment, and presenting this final composition as an augmentation of the original space (figure 1). Our physical configuration proposes to present this resultant composition at full scale as a mirror-like complement to the space of the users (figure 2)[7]. In this way, the user's doubling is also a spatial doubling, as the newly expanded space includes both the original space of the physical user and the image-based space of the double. The spatial construction of the synthetic environment is a physical manifestation of Morse's virtuality: a spatio-temporal multiplication of self through social mediation.

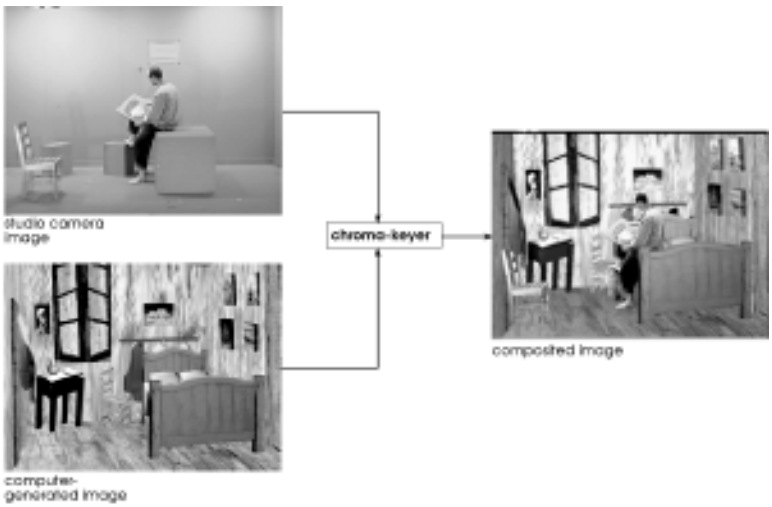

Figure 1. Example of the chroma-keying process, taken from an early prototype of the synthetic environment. Note the second-pass chroma-keying employed to composite the foot of the bed in front of the participant.

Figure 3 presents a diagram of the complete collaborative environment, which multiplies yet again the complete space of its operation. Each of the scenarios described above exists at one of two sites, and spatial and image data from each location is sent to the other. In this way, the space of the doubled user is also inhabited by remote participants. Interaction between participants at each site is facilitated in this part of the synthetic space. With this as the complete diagram for the synthetic environment, not only are the studio configuration and videographic design important components of the overall spatial configuration, but the imaging, tracking, collaboration enabling, and networking implementations become productively spatialized. Typical virtual set, virtual reality, or even augmented reality systems implement each of these systems through specialized technologies: image rendering and calibration software for imaging, optical or magneto-electrical hardware systems for tracking, sharing software and communication protocols for collaboration, and network-optimized video codecs for communication. The SSE, however, integrates these essential technical requirements into a single (spatial) problem. There are still specific technical specialties within this spatial development, but they are not seen as autonomous technical problems but rather as a single complex implementation. Through our consideration of the problem of the SSE within the domain of the *space of the virtuality* rather than the *technical requirements of a collaborative virtual set system*, we have shifted the primary focus from isolated techniques (manifested in particular technological products) into a complex socio-spatial system.

Figure 2. Representation of the mirror-like configuration for the presentation of the composited image to the SSE participants.

6 Implementation Detail

As the spatiality of the VSE relies upon many design variables that are interconnected, it is important that these be pursued in a parallel fashion. We can divide these variables into two general categories for the purpose of explanation: there are the traditionally spatial design variables, and the computation-based design variables. The first category includes both architectural and videographic variables like studio layout, lighting and acoustics, and camera direction; the second includes specific concerns of CGI implementation that affect the presentation and perception of space in the VSE like image fidelity, tracking accuracy and compression loss. While admittedly there is some autonomy of these two categories of variables from each other, our requirement is that the physical spatial arrangement and design of the shared VSE have a symbiotic relationship with the computational techniques employed. To date, we have implemented a Virtual Set system that offers the opportunity to examine the impact of the first category of variables on the space of the virtuality; before concluding, I will introduce our next phase, focusing on the spatial framing of the computational processes. We are at the beginning research phase of this work that will facilitate untethered camera and participant tracking, spatial consistency between multiple sites, and proper spatial composition of participants from any location

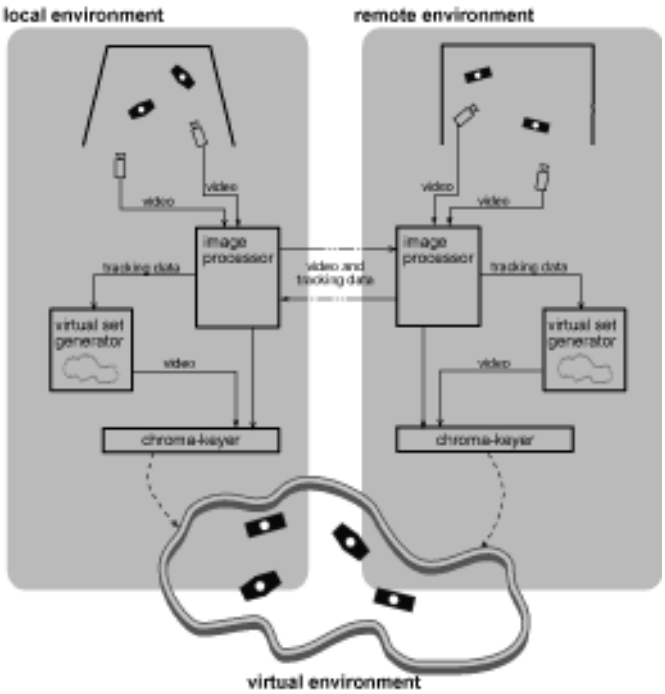

Figure 3. The overall diagram of the shared synthetic environment.

within the multiple sites. Within this framework, our main challenge is combining the images from the local site, the remote site, and the virtual model into a seamless image that appears consistent with a single viewpoint (which may be different at each site). This consistency must be maintained to present to all users a coherent and understandable representation of the spatial environment. Essentially, there are three problems related to the SSE, which we have framed as problems of camera-based tracking. First, the position and orientation of the studio cameras must be determined as they are moved around the local and remote sites in order to coordinate the movement of the camera in the CGI environment with the studio cameras. This coordination is required to properly position the SSE users in the CGI image. Second, the position of the users must be determined relative to the cameras and, using the camera's position and orientation information, relative to the local or remote site. This is required to properly position users from the local site in the proper spatial relationship to users in the remote site. And third, the two images of the users from the local and remote sites must be combined and transformed relative to the virtual camera within the virtual set to create the composite image. All of this must be done at or near the frame rate of the camera, and no slower than the lowest frame rate which is acceptable for avoiding time-based visual artifacts (generally accepted to be ten frames per second). This is all accomplished in the "image processor" areas indicated in figure 3.

Each of these problems has been studied extensively, with many results appearing in the research literature (Dhond and Aggarwal, 1989; Hartley, 1998; Kanade and Okutomi, 1994; McMillan and Bishop, 1995; Okutomi and Kanade, 1993; Seitz and Dyer, 1996; Stewart, Flatland, and Bubna, 1996). Our goal is not to invent new theory in addressing the problems, but rather it is to use spatial constraints that can naturally be imposed within the SSE to solve the problems reliably and efficiently. The resulting techniques, in particular, will not depend on the particular configurations of the cameras and the site; as components of a spatial system, they are transferable to a wide variety of environments and applications. The fundamental insight facilitating the diverse accomplishment of a single computational algorithm is the assertion of the primacy of space within the SSE. Specifically, this is due to three implementations: the use of chroma-keying to simplify the camera's image sources, the full-scale nature of the installation which requires only one point of view to be displayed to all participants at a site, and the use of the actual bodies of the participants rather than digital avatars to represent existence in the SSE. Each of these implementations is based on standard modes of spatial occupation: situating the place of interaction in a room rather than on a desktop, use of an architectural element (metaphorically, a mirrored wall) rather than an HMD to display output, and deployment of actual bodies rather than iconographic representations to situate participants in the virtuality.

7 Future Work

Our current implementation of the project is primarily concerned with the way in which we construct an appropriate spatial vocabulary in a complex mediated spatial condition. We have completed the development of a system which includes immersive three-dimensional computer-generated environments with static single-camera viewpoints, interactive computer-generated sets controlled by technicians and participants, and foreground matting which allows computer-generated objects to appear in front of participants as well as behind them based on a limited implementation of their z-depth tracking. Of the proposed model, we have yet to implement camera and participant position tracking or network communications of the shared site. Even at this stage, however, we have creatively engaged our spatial concerns through the development of live performances that address the complex nature of the proposed environment. These performances are a part of our preliminary design phase, and are surrogates for the type of spatial practices that we will need to understand when we finally engage participants at multiple sites. Even at this preliminary level, however, we have found the conceptual device of the virtuality to be quite instrumental in breaking through the continuous technical constraints that we have encountered. It will only be through the continued parallel development of such operative theoretical devices and iterative spatial implementations that this project will be able to challenge the assumptions embedded in VR technologies. For example, what is most significantly perceived as a limitation on immersive perception of the SSE is its mirror-like display. On one hand, we argue that, on the terms of human spatial perception, this is a more natural mode of spatial interaction and immersive presentation than those offered by HMD's, which require the portage of physically obstructive equipment, or of CAVE's, which even at best limit social interaction and present, across the well-defined edges of a cube, an ostensibly seamless image. On the other hand, we see a number of impending technologies that

could be absorbed into the space of the virtuality. Real-time filtering of background images could eliminate the need to be in a chroma-key studio, remote participants could be projected into the physical space (beyond the mirror) with three-dimensional holographic projection, or multiple-viewpoint enabled 3-D projection could replace our proposed 2-D projection.

While we are by no means uninterested in including such new technologies in the model of the SSE, it is not essential to our theoretical project. Above all, we are concerned with the meaningful socio-spatial development of new forms of intensely mediated environments. As technologies become available, they will be incorporated into the SSE only so long as they can be adopted within – and in close conjunction with – a spatial framework. Our process is one of a forced ambiguity between space and technology, a conjunction that is not exactly simple to maintain when working so closely with systems that prefer expected, enumerated, and consistent input. However, we believe it to be a process worth maintaining, lest we return again to uncritical oppositions. If the real is inseparable from the virtual, then so is the theoretical, from the applied.

Acknowledgements

I would like to acknowledge four individuals who have contributed greatly to this work. Most importantly, Kathleen Brandt, professor of video and installation art at Rensselaer, co-directed the performances that formed our first major public presentation of the SSE and has been a major influence on the creative and theoretical direction of our work. Karel Dudesek and Martin Schmitz, from the University of Applied Arts in Vienna, and members of Van-Gogh TV, have helped develop the shared model for the SSE and are our remote collaborators for our upcoming online-shared SSE experimentation. And Charles Stewart, professor of computer science at Rensselaer, has contributed substantially to the conceptual model for the computer imaging system that forms the core of the SSE. Without the dedicated support of these individuals, our work on the subject would have scarcely evolved.

References

American Heritage Dictionary. (1985). Boston: Houghton Mifflin Company.

Barfield, W., Zeltzer, D., Sheridan, T., and Slater, M. (1995). Presence and Performance Within Virtual Environments. In *Virtual Environments and Advanced Environment Design*, eds. W. Barfield and T. A. Furness. New York: Oxford University Press.

Castells, M. (1989). *The Informational City: information technology, economic restructuring, and the urban-regional process*. Oxford: Blackwell.

Cambridge Dictionary of American English (2000). Available from: http://www.cup.cam.ac.uk/esl/dictionary. Accessed April 15, 2000.

Darken, R. P., Allard, T., and Achille, L. B. (1998). Spatial Orientation and Wayfinding in Large-Scale Virtual Spaces: An Introduction. *Presence*, 7(2), 101-107. Cambridge: MIT Press.

Dhond, U., and Aggarwal, J. K. "Structure from stereo — a review." *1999 IEEE Transactions on Systems, Man, and Cybernetics* #19, 1489-1510.

Foucault, M. (1970). *The Order of Things*. New York: Vintage Books.

Hartley, R. "Minimizing Algebraic Error in Geometric Estimation Problems." *1998 IEEE International Conference on Computer Vision*, 469-476.

Hayles, N. K. (1999). *How We Became Posthuman : Virtual Bodies in Cybernetics, Literature, and Informatics.* Chicago, University of Chicago Press.

Heim, M. (1993). *The Metaphysics of Virtual Reality*. New York: Oxford University Press.

Kanade, T., and Okutomi, M. "A Stereo Matching Algorithm with an Adaptive Window: Theory and Experiment." *1994 IEEE Transactions on Pattern Analysis and Machine Intelligence*, 920-932.

Lefebvre, H. (1974). *The Production of Space*. Trans., Donald Nicholson-Smith. Oxford: Blackwell.

Lynch, Kevin. (1960). *The Image of the City.* Cambridge: Harvard University Press.

McMillan, L., and G., B. “Plenoptic Modeling: An Image-based Rendering System.” *SIGGRAPH ‘95*, 39-46.

Mirriam-Webster’s Collegiate Dictionary. (2000). Available from http://www.m-w.com/cgi-bin/dictionary. Accessed April 15, 2000.

Morse, M. (1998), *Virtualities: Television, Media Art, and Cyberculture.* Bloomington, Indiana University Press.

National Research Council (1995). *Virtual Reality: Scientific and Technological Challenges*. Washington D.C.: National Academy Press.

Okutomi, M., and Kanade, T. (1993). “A Multiple-baseline Stereo.” *IEEE Transactions on Pattern Analysis and Machine Intelligence*, #15, 353-363.

Ronell, A. (1989). *The Telephone Book*. Lincoln, University of Nebraska Press.

Schloerb, D. (1995). A Quantitative Measure of Telepresence. *Presence,* 4(2), 64-80.

Seitz, S. M., and Dyer, C. R. “View Morphing.” *SIGGRAPH ‘96*, 21-30.

Soja, E. (1989). *Postmodern Geographies: the reassertion of space in critical social theory*. London: Verso.

Stewart, C. V., Flatland, R. Y., and Bubna, K. (1996). “Geometric Constraints and Stereo Disparity Computation.” *International Journal of Computer Vision*, 20(3), 143-168.

Stone, A. (1995). *The War of Desire and Technology at the Close of the Mechanical Age.* Cambridge: MIT Press.

Strong, J. and Woodbury, R. (1998). “Psyberdesign: Designing the Cognitive Spaces of Virtual Environments.” *Digital Design Studios: Do Computers Make a Difference?, Proceedings of 1998 ACADIA conference.* Quebec City, Association for Computer Aided Design in Architecture.

Tolman, E.C. (1948). “Cognitive Maps in Rats and Men,” *Psychological Review* 55: 189-208

Vasquez De Velasco, G. and Hutchison, D. (1999). “An Immersive Environment for Virtual Design Studios.” *media and design process, Proceedings of 1999 ACADIA conference.* Salt Lake City: Association for Computer Aided Design in Architecture.

Zeltzer, D. (1992). Autonomy, Interaction, and Presence. *Presence,* 1(1), 127-132. Cambridge: MIT Press.

Zukin, S. (1991). *Landscapes of Power: from Detroit to Disney World*. Berkeley: University of California Press.

[1] From the online Mirriam-Webster Collegiate Dictionary, virtual is defined as “being such in essence or effect though not formally recognized or admitted” (Mirriam-Webster, 2000). The online Cambridge Dictionary of American English defines it to be “almost, but not exactly or in every way” (Cambridge Dictionary, 2000). And finally, a 1985 American Heritage defines it to be “existing or resulting in essence or effect, though not in actual fact, form, or name” (American Heritage, 1985).

[2] A possible weakness of her suggestion is that it privileges the self – the self before the transmission-imposed “you” or the interactivity-imposed “I” – as a self without subjectivity, where the self is somehow seen as actual fact; the subject as in-effect-but-not-in-fact. I accept this as a rhetorical weakness of the text, however, as Morse is clear to articulate that, within the complex realm of subjectivity formation, notions of original have little significance.

[3] I use Margaret Morse’s explicit concept of virtuality because of its clarity and relevance to my arguments herein. However, it is important to note that this notion, whether in name or not, has formed the basis of many writings on the virtual realm. In particular, I would like to acknowledge the writings of Michael Heim in *The Metaphysics of Cyberspace*, N. Katherine Hayles in *How We Became Posthuman : Virtual Bodies in Cybernetics, Literature, and Informatics* and Avital Ronell in *The Telephone Book* in influencing my work on the subject (Heim, 1993; Hayles,

1999; Ronell, 1989).

[4] An interesting exception to this can be found in "Psyberdesign: Designing the Cognitive Spaces of Virutal Environments" by Strong and Woodbury, where the authors explore the implications of using Kevin Lynch's (originally E.C. Tolman's) notion of a cognitive map to design virtual environments (Lynch, 1960; Tolman 1948). Nevertheless, my critique of the congnitive map model is that it fails to address the significant variable of social behavior and interaction in space. Meaningful spatial models for collaborative virtual environments should certainly take these social variables into effect.

[5] My exploration into myth is intentionally restricted to Barthes' formulation, which is quite distinct from the larger concept of social, historical, or cultural myths.

[6] Synthetic reality is defined as a general term by the National Research Council which includes virtual reality, augmented reality, and telepresence environments. I prefer the generic nature of this term and use it perhaps most importantly in our research to avoid problematic associations with the adjective "virtual" (National Research Council, 1995).

[7] This form of presentation is similar spatially to the work presented by Guillermo Vasquez De Velasco and David Hutchison from Texas A&M University at ACADIA 99. (Vasquez De Velasco and Hutchison, 1999)