Interfacing Virtual & Physical Spaces through the Body: The *cyber*PRINT Project

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Abstract

The *cyber***PRINT** is a fully immersive, interactive virtual environment that is being generated in real time based on physiological data readings of a human body. In other words, the *cyber***PRINT** is based on creating interfaces between physical and digital spaces and between biology and information technologies. The *cyber***PRINT** is also an event, wherein a performer is connected to the *cyber***PRINT** generator to create a self-sustaining feedback mechanism. Although the use of the body to electronically drive music and media events is not new, most of these works have paid little or no attention to the potential of *interactive 3D virtual environments*. Nor have they been so technologically advanced, interdisciplinary intensive (involving Architecture, Choreography, Modern Dance, Music, Bioengineering, Medicine and Computer Science), or architecturally focused as the *cyber***PRINT**.

This project covers a wide and fertile territory that goes from the very technical and design oriented to the very theoretical and interdisciplinary. This paper is intended to (1) expand what has been already published about this project (Bermudez et al 2000a) and (2) establish potential areas for discussion before and after the performance

1 Introduction: Why a Live Performance?

This paper provides background for the live performance of the *cyber***PRINT**, a real time, physiologic data-driven virtual architecture developed by an interdisciplinary team led by two architects during the past 5 years. The reason for this live performance and demonstration is simple. It is only through performance that we can show the true nature of the *cyber***PRINT**. Such demonstration will also provide empirical proof of the theoretical claims and technological details already published elsewhere (Bermudez et al 2000a). In addition, this version of the *cyber***PRINT** will add some novelties occurred

since then (such as a new virtual world, data-driven music in real time, a navigational data-globe). Images of a live performance are shown in Figure 1 below.

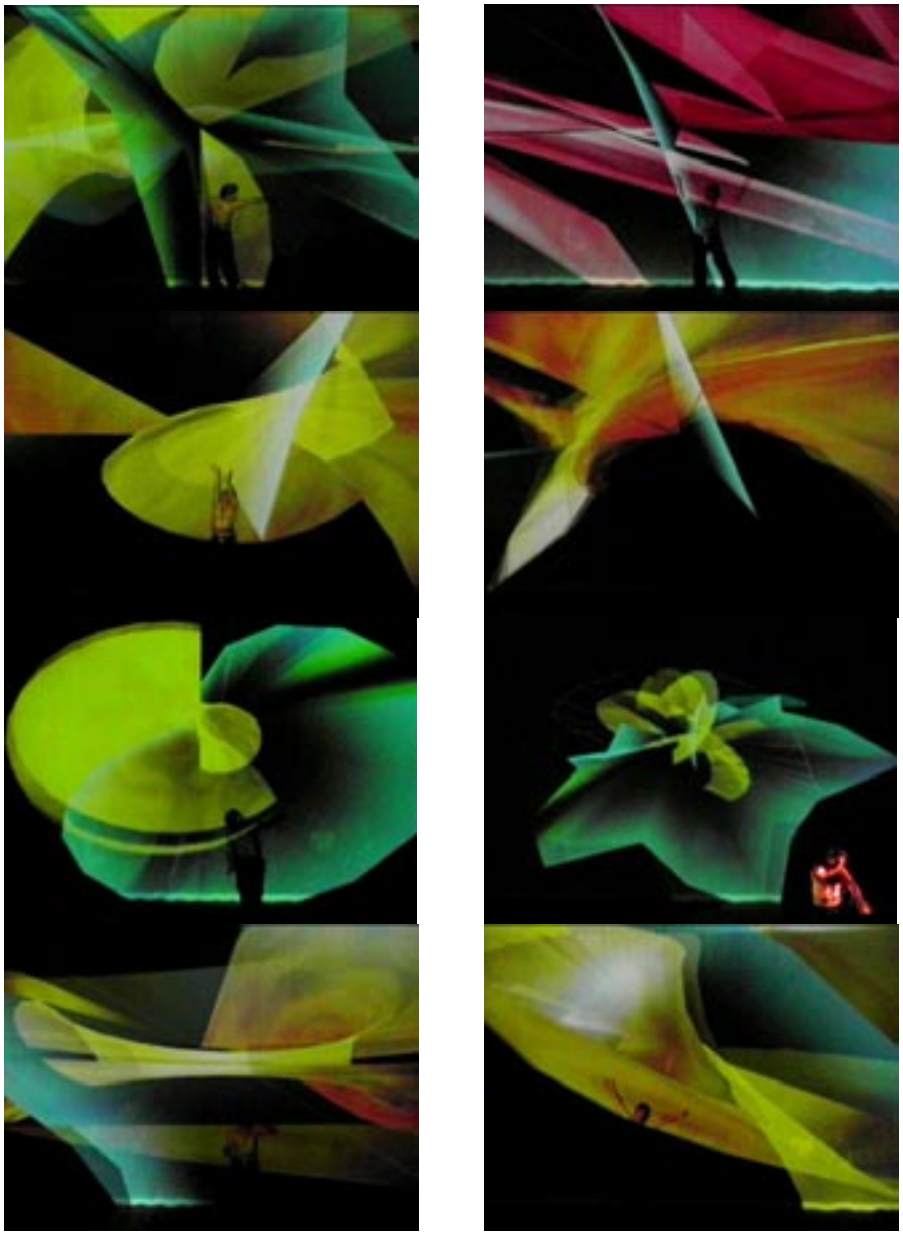

Figure 1. These images are video captures of a `cyber`*`PRINT`* performance on May 13, 2000 at the Rose Wagner Performing Arts Center in Salt Lake City, Utah.

2 Definition

The *`cyber`***`PRINT`** is a fully immersive, interactive 3D Virtual Reality environment that is being generated in real time based on the physiological data readings of a human body. Although the use of the body to electronically drive music and media events is not new

(Davies 1999, Novak and Sharir 1994, Kisselgoff 1998), most of these works have paid little or no attention to the potential of *interactive 3D virtual environments*. Nor have they been so technologically advanced, interdisciplinary intensive, or architecturally focused as the *cyber***PRINT**.

3 Performance

The *cyber***PRINT** is also an event, wherein a performer is connected to the *cyber***PRINT** generator to create a self-sustaining feedback mechanism: the user's performing environment is the "architecturization" and "musicalization" of their own body physiology. The performer inhabits and interacts with their *cyber***PRINT** by dancing, constantly changing their vital signs and thus keeping alive and continuously transforming the virtual space. Both the performer and the audience experience the *cyber***PRINT** through large screen projection technology.

4 Theory: Body & Space

The creation and development of the *cyber***PRINT** is based on creating interfaces between physical and digital spaces by means of the body. Or better said, we interface biology and information technologies to sustain the artificially virtual, that is, what we consider to be a new, cybrid Architecture —borrowing Peter Anders' term (1999).

Making the body the hinge point where virtual and physical spaces meet and express their temporal dialogue (i.e., the virtual is generated by the real but the real is affected and changed by what the virtual does) casts new light into what has become ordinary for most individuals in the first world: a schizophrenic coexistence of virtual and physical spaces at once. As intriguingly, it opens up the consideration of what may be called an ***"architecture of being"*** *that expresses anew the actual fluidity of the self in real time.*

The fact that we have created the technologically/architecturally virtual does not mean that we see this construct as any different from concrete tools born out of our bodies. Quite to the contrary, the *cyber***PRINT** proves the centrality of the body in a way that is related although more literal and visceral than the one envisioned by Karen Frank (1995, p.20). She says:

"My experience of virtual reality depends upon my physical body's movement ... To see I must move my head. To act upon and do things in a virtual world I must bend, reach, walk, grasp, turn around and manipulate objects ... If the virtual is so physical, what body will I leave behind? Not my physical body. Without it I am in no world at all. It is physical bodies that give us access to any world."

This line of inquiry is close to thoughts advanced by the work of Johnson (1987) and Lacoff and Johnson (1998) that demonstrate how the influences of the body can be found in even our most abstract (and hence seemingly non-corporal) constructs such as language and thought.

Using the unremovable foundation of the body allows us to explore the interface between virtual and physical spaces without having to resort to a dualist choice or dialectic compromise. Researching, designing, and performing symbiotic and/or hybrid spaces such as the one proposed by the *cyber***PRINT** expand and evolve the conceptual, disciplinary, and practical boundaries of architecture.

5 Interdisciplinary Collaboration.

The *cyber***PRINT** demanded a close relationship among Architecture, Bioengineering, Medicine, Computer Science, Choreography, Modern Dance, and Music. The methodology employed to come up with the working concept, technology and performance required lengthy interactions, new vocabularies, new engineering, etc. The design process, still the dominant method for carrying on the work, was further extended to include the methodology and techniques coming from different people and disciplines.

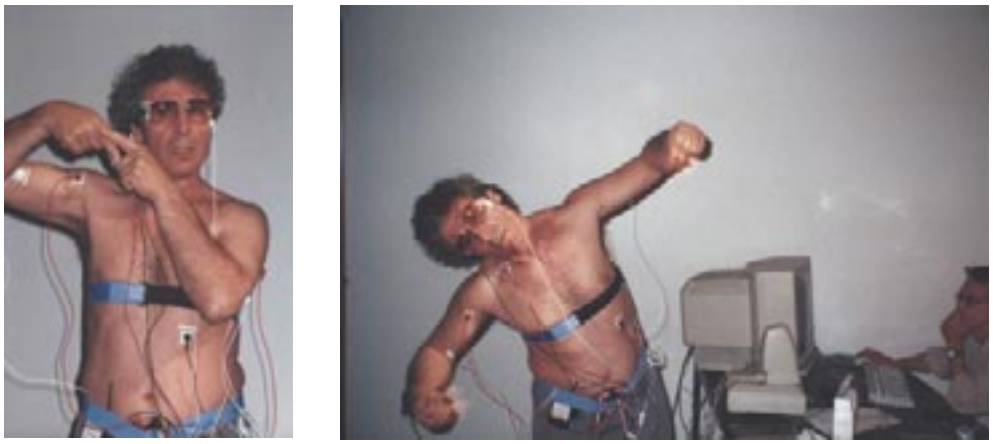

Figure 2. The physiological sensors of the BioRadio 110 are placed on the body of choreographer Yacov Sharir prior to the performance. The physiological data generated by his body are measured and radio transmitted to two networked PCs which are used to construct the virtual architecture or cyber*PRINT*.in real time.

6 Technology

Generating the *cyber***PRINT** in real time demands the collection, transmission, reception, organization, and manipulation of a constant and large stream of physiologic data. Although we utilize existing technology to wirelessly obtain the data from the body, we had to develop our own hardware and software tools to be able to utilize those signals in the ways required by our project.

The physiologic data is gathered from non-invasive medical sensors registering vital signs in real time in numerical data format. We utilize the BioRadio 110 made by Cleveland Medical Devices Inc. to accomplish this task (http://www.clevemed.com). The BioRadio 110 is a lightweight programmable wireless physiological monitor for measuring and recording EEG, ECG, EMG, EOG, and PSG signals. The apparatus sends

the measured data via radio signals directly to a PC where they are then pre-processed and immediately sent to another wintel computer with especially written, Open GL based software to generate the *cyber***PRINT**. See Figure 2. Given the intensive nature of the task that large amount of complex data, and real time processing, interactivity and 3D rendering demand, we use mathematical definitions of our architectures as a foundation to generate our Virtual Reality.

The *cyber***PRINT** is thus a true, fully immersive and navigable 3D Virtual Reality experience that is being generated in real time. The reason for using data projectors during performance is only one of practicality. It would be close to impossible to provide each member of a 100-300 people audience with a head mounted VR display. Refer to Figure 3 below.

Figure 3. The technology during performance. In the foreground Yacov Sharir is connected to the BioRadio 110; behind him (blurred by the flash of the camera) is the cyber*PRINT* projected directly from the computer where the data is transformed into a three- dimensional visualization in real time.

7 Design Method

"Architecturizing" body physiology is quite a task involving new challenges for our discipline: real time data-based form generation and morphing, totally interactive architecture, formal semiotics, mathematical encoding of space and form as well as the interface between the actual user and its real space with the generated virtual construct.

Since physiological data can be represented in any way within digital space, our work focused in the design of the visual-temporal prescriptions guiding the transformation of the incoming data into visualizable 3D representations. We heavily drew from "Basic Design" architectural knowledge, that is, the area concerned with formal composition as defined by basic principles (e.g., scale, shape, rhythm, color, structure, etc.), elements (e.g., line, figures, objects, space, etc.) and organizational rules (e.g., hierarchy, layering, symmetry, etc.) of 2D and 3D design.

The design method followed was simple and logical demanded many time-consuming interdisciplinary loops. First we developed different formal compositions using storyboards, trying to establish some semiotic relationship between collected vital signs (e.g., as referring to some particular physiologic function —the heart) and a particular virtual construct. In parallel to this process, we carried out basic data analysis trying to understand simple patterns in the information so that normal values, departures from the normal, interaction among variables, fusion potential, etc. could be determined. This study was very important for verifying (or not) early formal semiotic assumptions and ideas. Once certain desired aesthetic-functional outcome was reached, a digital static mock-up model was constructed (using ordinary 3D modeling software such as 3D Max or Form-Z) paying some attention to variables definition, change and integration. After appropriate reflection and feedback, selected forms were encoded into mathematical equations using Mathematica software and tested by running actual pre-recorded data (i.e., not in real time). See Figure 4. This often prompted diverse changes and adaptations. Finally, the design prescriptions thus established were written into a especially coded software as early described. Refer to Figure 5. The testing of the software in relation to design intentions took several iterations, each one involving multiple corrections.

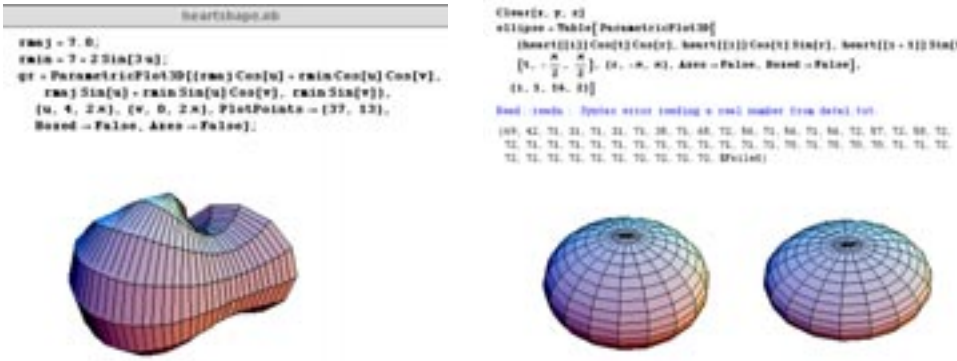

Figure 4: Once a satisfactory formal semiotic is reached, it is encoded into mathematical equation using Mathematica (left) and then tested using pre-recorded data (right). The positive or negative correlation between data and formal behavior is used to judge the appropriateness of the architectural design.

Figure 5: Screen images of the written software used to generate the virtual architecture which runs in Wintel machines. Considerable effort was devoted to make the interface able to represent the

various phases required to get the system running as well as to allow the always necessary design variations and data filtering prior to performance time.

We should add that it was the last 7 days prior to the first performance of the *cyber***PRINT** that brought the necessary intensity of effort, dialogue, intention and exploration to deliver the product. During that week, six people from 5 different disciplines work together around the clock in the very theater where the performance would take place. This interdisciplinary studio experience among professionals became hard at time and always stimulating. We cannot see how we could have done it without it. This probably shows that, very much like in the architectural design studio (be it in practice or in the office), it takes some level of pressure and intensity to deliver a highly complex product.

8 Research and Practice Potential

Working on this project made it clear that a new area of architectural theory and practice is possible. We call it Data Representation Design or Architecture. This new practice involves the invention of a language to express the logic of data so that users can easily understand patterns and emerging structures. This design-based technology is now patent pending and being applied to projects in Medicine, Finance, Systems Control and Network Monitoring. For a discussion on this line of inquiry refer to Bermudez et al (2000b).

Acknowledgments

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