Passages: An Artistic 3D Interface

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Abstract
"Passages" is an immersive, multimodal, user-controlled artistic interface. The installation consists of a 3D interactive virtual environment, stereoscopic projection screen, and a specialized haptic interface device (vibrotactile dataglove). Both the glove and the users' glasses are tracked by a long-range Polhemus electro-magnetic sensor in real time, allowing kinesthetic exploration of the virtual world while it is being created. The interface emphasizes not only what is seen or touched, but self-reflection on the perceptual experience itself.

Keywords
Immersive, kinesthetic, multimodal, enactive, haptic, vibrotactile, virtual environment, artistic interface.

ACM Classification Keywords
Categories and subject descriptors: H.5.2 [HCI]: User Interfaces---Haptic I/O, Interaction styles; J.5 [Computer Applications]: Arts and Humanities---Fine arts

Introduction
Increasingly, human expression, cognition and experience coexist with a complex and ubiquitous digital information environment. The design and use of perceptual robotic and virtual presence technologies, driven by human-centered ethnography, design research, cognitive psychology, and artistic process,

promises new opportunities for embodied creative and didactic experiences and the betterment of society at large. Today, the success criteria for new interface technology goes beyond its technological feasibility to the ability to which it satisfies overarching human needs [11]. Designers of new systems are not only asking what is possible or viable, but the degree to which emerging technology addresses the values, lifestyle, emotional state, and well-being of its users [8].

The author who most extensively explored the subject of human need was psychologist Abraham Maslow. In his writings, Maslow developed what he called a "Needs Hierarchy," ranging from "basic needs" such as physiological needs for air, food, water, etc., to "defense needs" for safety and security, to "social needs" for love, belonging, acceptance and respect. At the top of the hierarchy are what Maslow terms "Self Actualization Needs" or "Metaneeds," including the need for truth, beauty, playfulness and simplicity. While needs lower on the hierarchy will command attention if unsatisfied, this highest level addresses human aspiration and the need "to become what one is capable of becoming." [10]

Throughout history, the needs on the top of Maslow's hierarchy have been the focus of much artistic practice, yet there have been relatively few human-computer interfaces designed to satisfy them. "Passages" prototypes an immersive interactive experience that addresses these universal human needs and aspirations directly, and is thus intended for a global audience.

Installation Overview

The "Passages" installation is composed of a darkened room containing the projected virtual environment, Infitec stereo glasses and a vibrotactile dataglove, both of which are tracked in space by a long-range Polhemus electromagnetic sensor. One full wall of the room contains a stereoscopic rear-projection surface (powerwall), driven by two superimposed high-resolution projectors connected to the PC rendering the virtual world. Real time positional information of the user's hand and glove are processed by the Polhemus system and passed to the rendering engine on a central computer to generate the appropriate viewing angle for each of the user's eyes. The environment is written in XVR (eXtreme VR) [15], a C++-based scripting language designed for haptic device integration, high-speed graphics and online network rendering (the projected stereo environment runs within Internet Explorer).

The virtual world is designed to evoke an emotional experience of awe and discovery. The user's glove controls an expressive beam of light that changes color in response to objects in the environment as sparks fly from its fingertips, as shown in figure 1.

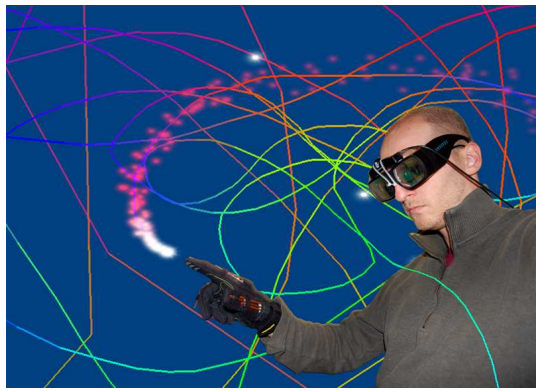

figure 1. A user immersed in the virtual environment.

Immersants in the installation expressively interact with an abstract environment centered on the concept of bodily knowledge and haptic consciousness. The trajectory of the glove traces visible colored lines through space that can be immediately explored and modified through further movement and touch. Guided by haptic, visual and audio feedback, the user's gesture becomes a direct form of multimodal composition, creating tangible lines and surfaces that can be manipulated, saved, and shared by future users. In this way the interface emphasizes not only what is seen or touched, but the perceptual experience itself.

Sensible Creativity and Embodied Interaction

The Western discourse on the hierarchy of senses has always relied on the traditional primacy of visual and auditory experience; a phenomenological analysis of olfactory, haptic, and gustatory experiences is lacking. Indeed, classical aesthetics has denied the artistic potential of such "lower" senses and relegated their experience into the realm of (un)pleasant sensations, asserting that the only artistically valuable senses are the "theoretical senses" of sight and hearing" [6]. Not only recent artistic developments, but also trends in research and technology, indicate a revival of the so-called bodily senses.

Because of its important role in Virtual Reality and Robotics research, haptics is becoming part of the techno-aesthetic experience and consequently of human perception. In the domain of the discourse about haptics, Walter Benjamin observed that as the aesthetic "aura" which sacralizes art objects by distancing their viewers begins to fade, there arises the possibility of "haptic awareness", an aesthetic experience based on the apprehensions of familiarity and habit, in terms of tactility, space and motion. Benjamin wrote that "the tasks which face the human apparatus of perception cannot be solved by optical means, that is, by contemplation alone. They are mastered gradually by habit, under the guidance of tactile appropriation" [5].

The title "Passages" is a reference to Benjamin's unfinished work "The Arcades Project" [3]. The Arcades Project consists of a huge collection of fragmented writings especially concerned with "passages", a typical Parisian architecture consisting of a walkway covered by a succession of vaults. These passages were full of meeting places, shops and cafés, and represented the hub of the city-life in the 19th century.

In his meditation on passages, Walter Benjamin adopted the concept of flânerie (meaning to stroll, to walk in a leisurely way, to wander). This concept was first used by Baudelaire and later inherited by many of the artistic avant-garde of the 20th century, especially the Surrealists. These artists transformed the concept of flânerie into a creative methodology aimed at achieving artistic inspiration, even in an artistic performance itself (as in the Situationist "dérive" or psychogeography). In these practices, urban observations can be exploited as an analytical tool, and perception achieved by means of walking and exploring: under the passages, understanding and expression are mediated by the bodily act of the flâneur. In the same way, in the installation Passages bodily perception and action are gathered in the hand's gestures, mediated by the glove. "Passages" also refers to the traces left by the actions of each user as they interact with one another over time and create a landscape of motion, the tracing of the physical movement of subjects within a space

As the human/machine dialogue becomes increasingly multimodal and defines new sensorial categories, digital technology (and in particular virtual reality) is often criticized for leading the perception of our bodies towards dematerialization. However, applied research has already moved towards the possibility of establishing a contact point between the body and the computer.

Human interaction with the world is a continuous, body based activity. To achieve more natural human–machine communication, it is important that systems support such continuity. Basic HCI tasks such as steering, aiming, or dragging all demonstrate the central importance of continuous feedback and control. Passages presents an artistic interface that goes beyond icons, symbolism and interface metaphor to become both fluid and embodied. This approach builds on a recent trend in philosophical and cognitive models of the human mind that understands all linguistic and iconic knowledge as "embodied" action [7, 14].

Unlike many creative digital tools, the intent of Passages is to address the creative process directly by exploring beyond the limitations of discrete applications and domains. While many artistic interfaces (such as the Adobe creative suite [1], for example) provide tools enabling users to design information in a wide variety of formats (graphics, print publications, online interactions, etc.), they are constrained by traditional mouse/keyboard interaction paradigms. This stands in contrast to the history of artistic practice, where spatial experience and the artist's physical manipulation of material has always been of central concern. In this sense, the concept of "action painting" pioneered by the abstract expressionists still plays a central role in the creation of fine art, not to mention the entire realm of performing arts (including drama and dance) where the development of human-computer interface applications poses much greater challenges.

Multimodal Integration

Today's body-driven artistic projects can benefit from a variety of tools allowing real time information capture, and use this information creatively to generate or drive lights, music, graphics, or video via a variety of commercially available motion tracking systems [13]. Electromagnetic tracking such as the Polhemus system used in Passages provides high spatial precision with low encumbrance and ease of use.

In Passages, the entire environment is an extension of the user's hand, its traces forming a continuous visual and tactile landscape. The effect is further emphasized by tracked stereoscopic immersion into the generated space, and audio feedback responding to user activity within the environment.

Passages explores creative embodiment through user movement and vibrotactile haptic feedback. Interfaces providing vibrotactile feedback have been shown to increase immersivity and provide effective aids to accelerated human motor learning [2, 9]. The PERCRO dataglove used in this installation (see figure 2) is based on new flexible goniometric sensor technology, characterized by its low cost and rugged construction that no requires calibration before use. The glove measures the angular displacement of the fingers using 11 sensors, and each sensor has a resolution of 0.2 degrees with 1 degree of accuracy. The communication between the Dataglove and its computer Host uses a 2,4 Gigahertz Wireless Bluetooth radio protocol guaranteed at a range of up to 10 meters with a refresh rate of 60 Hz.

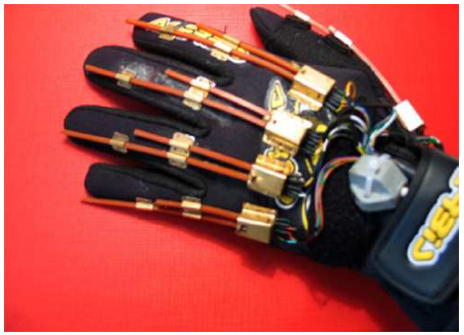

figure 2. The PERCRO dataglove.

The glove is particularly well adapted for public installations as it requires no calibration before use and therefore accommodates a wide variety of hand sizes, finger thicknesses, and ranges of motion. In addition to sensors measuring the relative angular displacement of the joints of the hand, vibrotactile actuators on the tips of each finger allow the artifacts of previous user activity to be "touched." The degree of vibration for each finger is a fluid relationship between the hand's position, movement, and interaction with objects in the environment. In addition, the gesture formed by the user's hand (opened, closed, pointing, etc.) controls the behavior, color and sound of the form being traced.

Conclusions and Future Development

Passages is an ongoing project exploring the expressive potential of multimodal environments. Although the current phase of the project has been completed, many additional software behaviors are currently under development. In particular, real-time gesture recognition is an important area of research with a wide array of potential applications in many fields, including dance, sport, physical rehabilitation, manual communication, motor learning, education, and new human-computer interaction paradigms. There are many approaches to the design of gesture recognition systems [16], and diverse methodologies for the modeling, analysis and recognition of gestures in real-time are being explored for possible integration into the Passages system.

In a related project, for example, an optically based gesture recognition system has been designed and tested to explore issues related to sensory-motor capturing [12]. In these experiments, two neural networks were used to recognize the gestures: a Feed Forward Neural Network (FFNN) and a Probabilistic Neural Network (PNN) [4]. PPN has been shown to provide 98% accuracy for gestures with a clear starting and stopping position. Extending this technology to account for the continuous motion of gesture sequences in an environment such as Passages is a challenging area of research currently being investigated.

Accompanying these developments, improvements to the reactive virtual environment will be developed to test the efficiency and implications of gesture learning on a variety of different users and situations. For interactive learning environments in particular, performed data could be mined by an intelligent system to understand which aspects of movement are similar and how a user's gestures evolve as they learn. Opportunities incorporating real time machine learning and interactive human/system interface didactics would be interesting to apply in a networked environment where a variety of users collaborate to teach the system—and each other—the fundamentals of new invented and/or improvised collaborative performance.

Acknowledgements

"Passages" is an evolution of continuing research at the PERCRO Laboratory, Scuola Superiore Sant'Anna in Pisa, Italy. Funding for research activities has been provided by two EU funded projects: The Enactive Network of Excellence, through which the installation will be shown at the scientific and artistic event "Enaction_in_Arts" 2007 in Grenoble, France (http://www.enactivenetwork.org), and the SKILLS IP consortium, an EU project dealing with the acquisition, interpretation, storing and transfer of human skill by means of multimodal interfaces, robotics and virtual environment technologies.

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Interactivity Supplement
CHI 2008

The Interactivity Supplement shows how conference attendees will interact with your work at CHI 2008. It is intended to give as rich a picture of your project and presentation requirements as possible. **This document is for the purposes of review only and will not be published.**

To explain how your project works, you can for example provide a short usage scenario, a storyboard sketch, screenshots, illustrations, and/or photos.

The Supplement also includes the various technical requirements such as preferred setting, space, power, networking, lighting, acoustical, and other special equipment.

It is important to remember that the reviewers of Interactivity submissions can only make decisions based on the knowledge contained in this document, the extended abstract, and the optional video. Therefore, it is through the supplement that you have the opportunity to informally describe how you envision CHI 2008 attendees interacting with your piece.

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DESCRIPTION

Title: Passages: An Immersive 3D Interface

Project Description (100 words max):
"Passages" is an immersive, multimodal, user-controlled artistic interface. The installation consists of a 3D interactive virtual environment, stereoscopic projection screen, and a specialized haptic interface device (vibrotactile dataglove). Both the glove and the users' glasses are tracked by a long-range Polhemus electro-magnetic sensor in real time, allowing kinesthetic exploration of the virtual world while it is being created. The interface emphasizes not only what is seen or touched, but reflection on the perceptual experience itself.

PRESENTATION HISTORY

"Passages" is an evolution of continuing research at the PERCRO Laboratory, Scuola Superiore Sant'Anna in Pisa, Italy. To date the installation has not been shown publicly, however it has been accepted to the scientific and artistic event "Enaction_in_Arts" which will be in Grenoble France from November 19-23, 2007 (http://www.enactivenetwork.org). This will provide an opportunity for revisions and updates to be made to the demonstration before SIGCHI 08, if necessary. The installation provides users with a personal, creative environment highlighting the intuitive and expressive potential of immersive multimodal virtual reality. In particular, the system integrates vibrotactile feedback with real-time stereoscopic vision and sound. An image of the user experience is shown in figure 1.

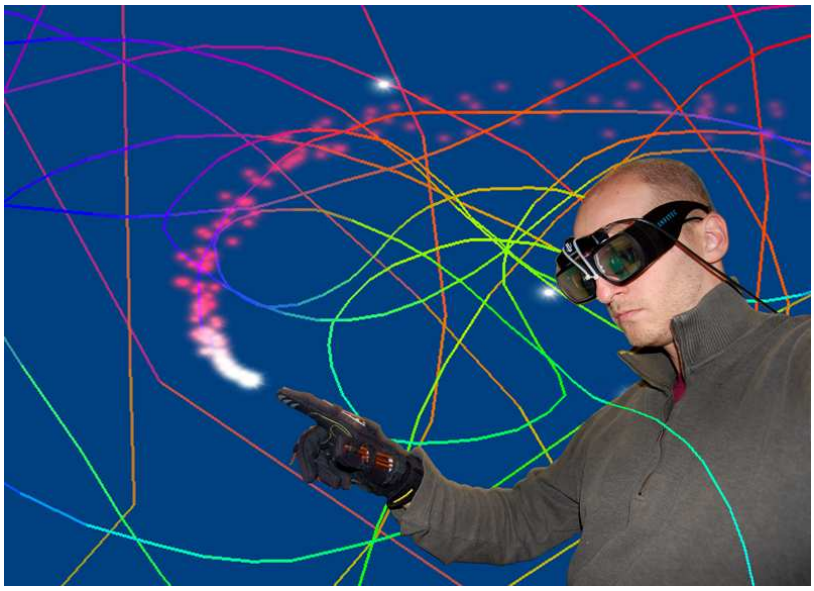

figure 1. *A user immersed in the virtual environment.*

ENVISIONED INTERACTION

Passages is a fully immersive virtual reality installation, requiring that only one visitor may use the demonstration at a time. A full-time assistant will be on hand to assist the user and keep waiting visitors in an orderly line. Less than two minutes is sufficient time for each user to fully experience multimodal interaction.

Each user entering the space will be instructed to put on a pair of tracked stereoscopic glasses and a PERCRO dataglove. This glove is based on new flexible goniometric sensor technology, characterized by its low cost and rugged construction (see figure 2). The glove is particularly well adapted for public installations as it requires no calibration before use and accommodates a wide variety of hand sizes, finger thicknesses, and ranges of motion.

figure 2. *The PERCRO dataglove.*

One full wall of the room contains a stereoscopic rear-projection surface (powerwall), driven by two superimposed high-resolution projectors connected to the PC rendering the virtual world. For this reason, the demonstration space should be somewhat enclosed or relatively dark. The ideal configuration would allow visitors passing through the Interactivity exhibition to see the interface from a distance. The dimensions of the projected surface are approximately 2 x 2.5 meters.

To use the demo, users simply face the powerwall and wave their hand in front of themselves. This movement will generate a visible trail of light through the virtual space, accompanied by vibrotactile feedback and sound. After having created an initial drawing for the first 30 seconds or so, the user will be encouraged to move into the space—walk towards the screen, kneel down, etc.—to explore and interact with the drawing he or she has created. For a visualization of output from the virtual environment, please see the (very) brief video documentation we have submitted along with this application.

TECHNICAL REQUIREMENTS

The technological components of this installation are:

1) Powerwall
    a. 2 High resolution projectors with Infitec filters
    b. Infitec glasses
    c. Rear projection screen
    d. Two large first-surface mirrors (if necessary)
    e. Black cloth panels (scenography) to beautify the space
2) PERCRO vibrotactile dataglove
3) “Slave” PC (this computer drives the rendering)
4) “Master” PC (laptop, control terminal for driving the demo)
5) Polhemus tracking system
    a. Electromagnetic source
    b. “Liberty unit”
    c. Two sensors, attached to the glove and the glasses, respectively
6) Audio speakers
7) Software (XVR, virtual environment, network renderer, associated plugins)
8) Relevant cables and powerstrips

All of these components are currently operational in our laboratory in Pisa, Italy, less than 60km from Florence, and we can bring them easily. An installation overview is shown in figure 3.

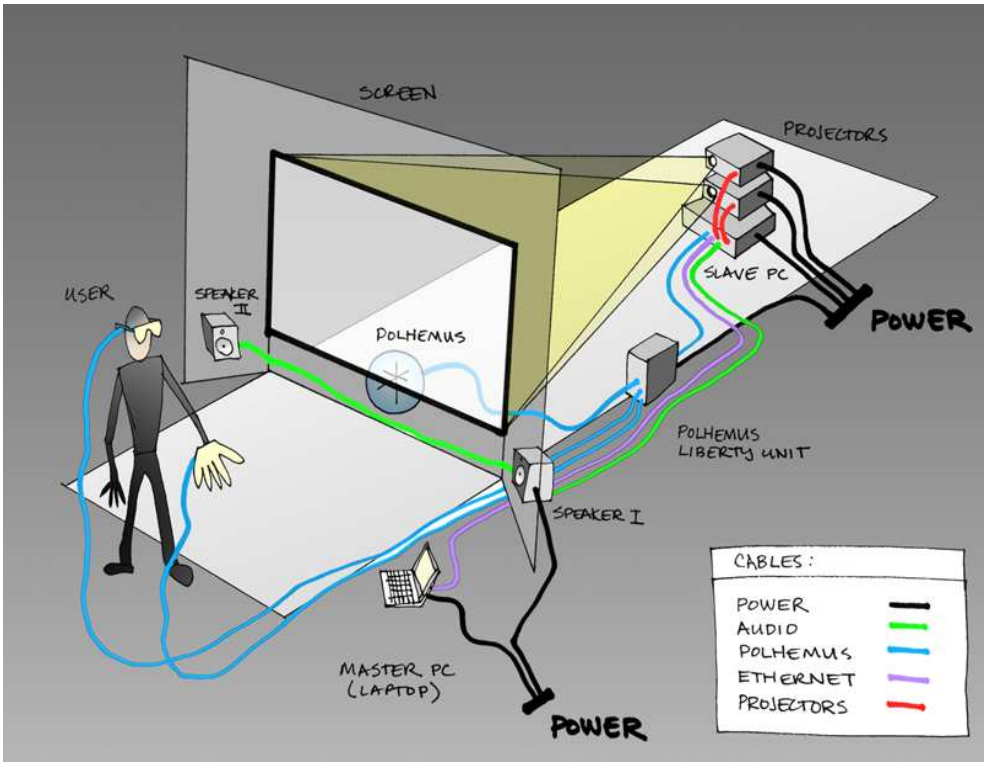

figure 3. *Installation overview: technical components for “Passages”*

INTEGRATION OVERVIEW

The demo is driven from a “master” PC (laptop) in the demonstration environment. This PC has complete access to the software driving the demo, allowing the demo assistant to easily reset the demo or clear the environment for each subsequent user. The virtual environment is written in XVR (eXtreme VR), a C++-based scripting language designed for haptic device integration, high-speed graphics and online network rendering (the projected stereo environment runs within Internet Explorer).

The master PC is connected via a direct Ethernet link to the “slave” PC via a special real-time network rendering software. The projectors, Polhemus tracking system, and audio speakers are all connected to the rendering software on the “slave” PC. Real time positional information of the user’s hand and glove are processed by the Polhemus system and passed to the rendering engine to generate the appropriate viewing angle for each of the user’s eyes. This PC interprets the relevant information, projects the environment, and outputs audio information. Control of the vibrotactile haptics on the user’s glove is driven by a wireless Bluetooth connection to the “slave” PC.

The space is divided into two principal areas: the “demonstration area” in front of the screen, and the “back-stage” area behind the screen which is off-limits to visitors. All of the hardware can be powered off two powerstrips, with extension cords if necessary, to a power socket near the space (ideally “back-stage”). A floorplan for the installation is shown in figure 4.

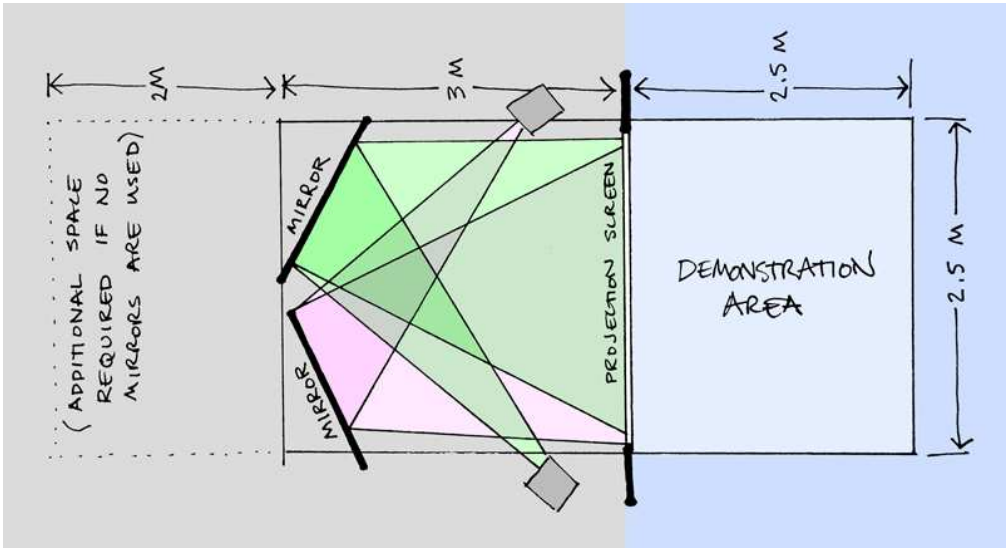

figure 4. *Installation overview: technical components for “Passages”*

If necessary, two large first surface mirrors can be provided to shrink the required space “back-stage” from 5 to 3 meters deep. The *minimum* space requirements

for the installation are therefore 2.5x2.5 meters for the demonstration area, with an additional 2.5x3 meters behind the screen, for a total area or 2.5x5.5 meters. This is a minimum. Additional space would be nice, as it allows room to work and can make installing the demonstration less complicated. If there is room to avoid using mirrors, this can also simplify the installation. Any ceiling height greater than 2.5 meters is fine.

ADDITIONAL REQUIREMENTS

As noted above, a darkened environment would be preferable, or one with controllable lighting. If it is possible to “hide” the backstage area in some way this would also be preferable, but depends heavily on the space available. No special carpets or flooring are required.

The Polhemus system is electromagnetic, and requires that there be no massive conductive (steel) objects nearby. The range of the system is 5 meters from the source, so any objects in this area could be problematic. Radiators and steel ceiling beams are the two most common sources of interference. Small objects such as other computers, etc. are not such an issue.

The demonstration generates audio, but this is not a critical component. Volume levels can be adjusted to fit the space, and audio bleed from other installations will not interfere.

The demo can run throughout the conference with no problems. The software and mechanical components are all extremely stable.

The demo does not require a network connection, but does use Bluetooth technology. The communication between the Dataglove and its computer Host uses a 2,4 Gigahertz Wireless Bluetooth radio protocol guaranteed at a range of up to 10 meters with a refresh rate of 60 Hz.

The demo will require two power sockets that can be split as needed with powerstrips.

Additional questions or concerns should be covered in our extended abstract. Thanks!