Creative Collaborative Exploration in Multiple Environments

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Abstract

We seek to support creativity in science, engineering, and design applications by building infrastructure that offers new capabilities for creative collaborative exploration of complex data in a variety of non-traditional computing environments. We describe particular novel environments and devices, including the Allosphere and the interactive Fogscreen, the software components to support collaborative interaction in mixed-media environments, and several key application scenarios that will leverage these capabilities. Our main focus is on supporting integrated visualization, sonification, and interaction capabilities in and across novel computing environments.

Introduction

To support creativity in science, engineering, design, and art, we are creating technologies to provide opportunities for rich data exploration and collaboration among multiple participants in a variety of environments. Rather than relying on a single tool and environment to support the creative process for a given class of problems, we seek to provide an array of experiences that can lead to different perspectives and insights. The intuition behind the approach is that the process of discovery, including analysis, synthesis, and creation, is constrained by the particular mediating tools and technologies, and thus providing a variety of rich environments that encourage collaboration and exploration will allow new ideas and approaches to emerge that might otherwise be difficult to conceive.

More specifically, we are investigating the use of visualization environments that utilize a range of display technologies and modalities, as well as collaboration techniques, applied to particular problems of scientific and artistic exploration. From small portable computing devices (such as cell phones or PDAs) to large, fully immersive display environments to novel display technologies, we wish to leverage the strengths of each in terms of visualization, sonification, and interaction techniques, and to provide for cross-platform and cross-modality collaboration capabilities. For example, a problem in molecular dynamics might seek insight into protein structures by exploring the interactions of molecules in a solvent. Tools such as VMD (Humphrey, Dalke, and Schulten 1996) are commonly used in this community, but the tool fundamentally limits exploration and thus insight in its typical workstation-level implementation. We seek to provide alternative windows on such problems though different interactive environments and a range of collaborative possibilities. We are collaborating with colleagues in several scientific disciplines, such as chemistry, nanoscience, neuroscience, and geoscience.

Generalizing a typically single-user tool into a multifaceted, community-use tool can open up new creative and synergistic approaches to scientific problems, with insight natural to one environment leading to new explorations and insights in the other environments. Similarly, for digital artists, musicians, and designers, we aim to provide new canvases that naturally incorporate collaboration and multiple conceptual viewpoints. Our current range of "canvases" includes two very novel interactive visualization environments: various configurations of the interactive *Fogscreen* display (an immaterial display that uses a thin layer of mist as a display surface) and a large, multi-person, sensor-rich spherical display environment called the *Allosphere*.

In addition to providing a common software interface that spans a range of computing environments, this agenda requires investigation into collaboration techniques across such environments, as well as social aspects of

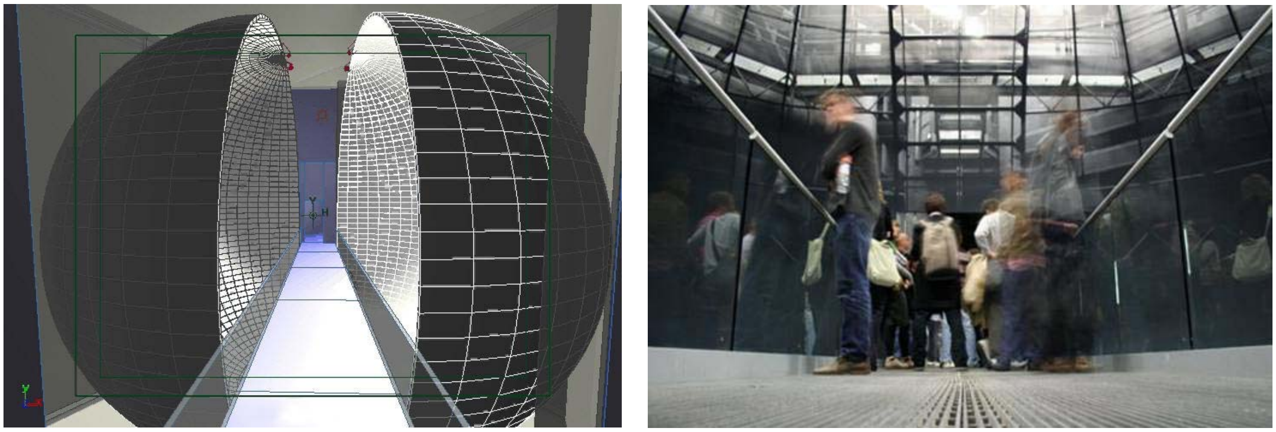

Figure 1. Left: A rendering of the Allosphere, as seen from the entrance, looking down the bridge. For visibility purposes, screen segments above the bridge have been omitted. Right: Visitors on the Allosphere bridge. Background illumination shows the perforated screen panels.

collaboration. How can scientists and artists, many who are trained to work individually and with complete control of the process, be motivated to explore a different model of approaching their work?

This paper describes work in progress, initial steps toward a long-term goal. In the following sections we describe the hardware and software infrastructures we are designing and building to support creative collaborative exploration, as well as a set of application areas and scenarios that will serve as testbeds for deployment in areas of science, education, and design.

Environments for Creative Collaboration

We are designing, building, and working with a number of environments and devices that aim to support a wide variety of opportunities for creative work and collaboration. These are not intended to replace more traditional computing devices, but to extend them and to provide a continuum of productive environments, from mobile handheld to office desktop to fully immersive, and to support (ideally device-independent) collaboration. This section describes three novel components: the Allosphere, the interactive Fogscreen, and novel input devices.

The Allosphere. The *Allosphere* (Amatriain *et al.* 2007) is a large, immersive, multimedia and multimodal instrument for scientific and artistic exploration being built at UC Santa Barbara. Physically, the Allosphere is a three-story cubic space housing a large perforated metal sphere that serves as a display surface (Figure 1). A bridge cuts through the center of the sphere from the second floor and comfortably holds up to 25 participants. The first generation Allosphere instrumentation design includes 14 high-resolution stereo video projectors to light up the complete spherical display surface, 256 speakers distributed outside the surface to provide high quality spatial sound, a suite of sensors and interaction devices to enable rich user interaction with the data and simulations, and the computing infrastructure to enable the high-volume computations necessary to provide a rich visual, aural, and interactive experience for the user. When fully equipped, the Allosphere will be one of the largest scientific instruments in the world; it will also serve as an ongoing research testbed for several important areas of computing, such as scientific visualization, numerical simulations, large-scale sensor net-works, high-performance computing, data mining, knowledge discovery, multimedia systems, and human-computer interaction. It will be a unique immersive exploration environment, with a full surrounding sphere of high quality stereo video and spatial sound and user tracking for rich interaction. It will support rich interaction and exploration of a single user, small groups, or small classrooms.

The Allosphere will be differentiated from conventional virtual reality environments, such as a CAVE (Cruz-Neira *et al.* 1992) or a hemispherical immersive theater (Gaitatzes *et al.* 2006), by its seamless surround-view capabilities and its focus on multiple sensory modalities and interaction. It will enable much higher levels of immersion and user/researcher participation than existing immersive environments.

The Allosphere research landscape comprises two general directions: (1) computing research, which includes audio and visual multimedia visualization, human-computer interaction, and computer systems research focused largely on the Allosphere itself – i.e., pushing the state of the art in these areas to create the most advanced and effective immersive visualization environment possible; and (2) applications research, which describes the integration of Allosphere technologies to scientific and engineering problems to produce domain-specific applications for analysis and exploration in areas such as nanotechnology, biochemistry, quantum computing, brain imaging, geoscience, and large-scale design. These two types of research activities are different yet tightly coupled, feeding back to one another. Computing research will produce and improve the enabling technologies for the applications research, which will in turn drive, guide, and re-inform the computing research.

The Interactive Fogscreen. The interactive dual-sided Fogscreen (DiVerdi *et al.* 2006) is a novel immaterial projection display which produces a thin curtain of water particles, so thinly dispersed in air it feels dry to the touch, serving as a translucent projection screen that can display images that seem to float in mid-air. Different images can be projected onto both sides of the screen, and users can freely reach or walk through it. The dual-sided nature of the Fogscreen allows for new possibilities in multi-user face-to-face collaboration and 3D visualization. Tracking the user provides opportunities for interactive applications with the device.

While fundamentally a 2D display technology, we are extending the basic Fogscreen to become a pseudo-3D display, via dual-sided rendering, head-tracked rendering, stereoscopic imaging, and the exploitation of the depth-fused 3D (DFD) effect when a tracked observer views graphics that are carefully arranged on several layers of fog to fuse to a 3D image. This will produce the world's first walk-through volumetric display.

The immaterial nature of the display is important for enabling new interaction possibilities. While two traditional displays mounted back-to-back could present a similar display to multiple users, the opaque displays would prohibit users from effectively collaborating across the two displays by obscuring users' views of each other, distorting speech, and making it difficult to pass physical objects across the display. This permeability of the Fogscreen is important not only for collaboration but also for the potential for direct interaction with the 3D scene. To enable interaction with our immaterial display, we are working with a number of tracking systems and novel input devices.

Novel Input Devices. An important part of our vision for fostering creative collaboration is the flexible deployment and use of traditional and novel interaction devices. Inspired and guided by musical and media arts performance and by creative artistic exploration, we have designed a large set of novel user interface devices (Kuchera-Morin *et al.* 2007, Overholt 2005, 2006). One such example is the spherical input device for controlling data in the Allosphere, depicted in use in Figure 2. We developed this custom interface device, called the Sphere Spatializer for the AlloBrain project (Wakefield *et al.* 2008) – an interactive experience in the Allosphere – in order to provide audiovisual navigation within fMRI brain-scan data and control semi-autonomous software explorer agents via custom Inertial Measurement Units (IMUs) based on the CREATE USB Interface (CUI) (Overholt 2006). In the AlloBrain, sound spatialization and visual navigation are controlled by two collaborating users. The CUI circuits are enhanced with Bluetooth wireless data transmission and the integration of multiple MEMS sensors, including 3-axis accelerometers, gyroscopes, and magnetometers. The orientation of each interface can be derived from the real-time sensor data, and users can choose navigation modes and/or control the software agents via buttons on the interfaces. The Sphere Spatializer has twelve buttons evenly spaced around its surface in order to control application parameters.

Figure 2. The Sphere Spatializer in use in the Allosphere

The form factor of the Sphere Spatializer is based on a hyperdodecahedron (a 4-dimensional geometric polytope), projected into 3 dimensions. It was developed using procedural modeling techniques, with the mathematical shape algorithmically sculpted to provide an organic and ergonomic look and feel that is aesthetically linked to the interactive content in the AlloBrain project. It was constructed with a 3D printer capable of building solid objects.

Another example of a novel interface we have developed for use in the Allosphere is an array of six capacitive E-field sensors embedded into the handrails on the bridge. This functions as a multi-person interface that maintains the multimodal use of handheld devices for the primary users, while providing a non-contact virtual presence to any secondary users present on the bridge. As with the AlloBrain project, primary users can control navigation in a virtual world through the use of a 3-DOF or 6-DOF Inertial Measurement Unit (IMU) devices, and the proximities of all users can be continuously sensed through the E-field array. The array is sensitive enough that a single user standing at any location on the bridge can be sensed, allowing a low-resolution spatial location to be derived. In addition to the analog proximity sensing, a simple threshold analysis provides discrete on/off touch functionality to the handrails by detecting when a user is in contact with them.

With the E-field sensors, group efforts of secondary users can manipulate either ancillary components of the primary user's navigation (i.e., camera zoom), or peripheral components of a simulation, such as the activity level of intelligent agents in the simulation (by moving towards the hand rail that is closest to the area of the virtual simulation they would like to have the agents explore). Collaborative sensing environments such as the Allosphere can blur the distinctions between those who directly interact and those who observe, by allowing primary and secondary users to simultaneously control different aspects of a simulation. For example, in digital musical ensembles audience members can be joint performers, or produce secondary effects on a primary performer's sound. Novel interfaces such as those described here are what allow these new possibilities to be explored.

Software Infrastructure

We are working on several pieces of a common software middleware infrastructure to enable and stimulate the envisioned collaboration among scientists, artists, and media designers. In this section, we present the design of four interoperable pieces of software, which correspond roughly to four levels of abstraction: (1) The **DII** component addresses input device and data integration; (2) the **MINT** framework provides multimedia service discovery, hardware-independent rendering, and application support; (3) the **InViTe** layer supports multimedia-augmented video-based distance collaboration; and (4) the **Soundium** environment provides support for multimedia authoring in novel ways.

DII. On the input and interaction-device side of our multimedia support infrastructure, we have developed a module called the Digital Information Interactor (DII). It is an interactive processing environment into which multiple users with various devices can enter and synthesize and/or process mathematical data visually and sonically. The system consists of a shared, global set of discrete sample and event data and a software interface so users can define custom behavior for generating audio, rendering graphics, and mapping input device data. The system is based on a model-view-controller pattern variant (Burbeck 1987).

The primary aim of the DII is to provide a centralized computational space that lies at the juncture of various physical sensing and rendering devices. The general notion of this approach is that multiple users work on a common set of data and at the same time provide custom functionality for their interaction with the data. We aim to enable use of the largest possible set of interaction devices, including the examples from the previous section, as well as standard VR devices, interfaces, and newly assembled input devices.

In our first test scenario for the system, we created a collaborative musical painting environment. In this system, each user brings in his or her own input device (we tested mice, game controllers, the MMI, and a whiteboard tracker) which is represented on a common 2D canvas as a cursor showing its current position. Each user had both a pointing avatar controlled by their input device data and a gesture avatar signifying the recording and playing back of their motions. By holding down the primary button of the device, its motions would be recorded and upon release the gesture would be played back in a loop. By dragging with the secondary button, the recorded gesture could be rotated independently along the x or y axis resulting in a phase-shifting transformation resembling those encountered with Lissajous figures, which are graphs of systems of parametric equations describing complex harmonic motion. In this particular setup of the DII, when a user’s gesture avatar entered or left a cell, it would respectively increment or decrement the cell's value. This provided a simple means for performing collision detection. Upon a collision, the gesture avatar synthesized a sinusoid run through a delay-line, where the point of collision determined the sinusoid pitch and the delay time.

This simple system proved quite effective as a multi-user musical performance environment and could be easily extended to provide more complex means of playing back gestures. We feel that the user customizability of interactions with the space, audio synthesis, and graphics rendering provides a general approach to working with data far beyond this musical testbed.

We plan to extend the interaction capabilities within the DII space as an interactive processing and synthesis environment to include a common set of algorithms for generating and processing data and mathematical models visually and sonically. Each user can join any number of DII spaces and generate or process information therein, depending on the data that is being generated or analyzed. Working with partner scientists in theoretical quantum computing, we plan to visualize and explore the equations that describe intermodulation among quantum dots, letting different scientist explore the mathematical nature of their inter-coupling.

MINT. On the next higher abstraction level, MINT is an open source multimedia framework designed to enable new media art and scientific research by providing a consistent structure as a C++ meta-library which integrates specialized libraries from different disciplines. MINT is focused on real-time visualization, performance, sound and rendering in a range of environments. Its goals include support for common tasks in both science and the arts, such as automatic cluster-rendering configuration for arbitrary displays, seamless video and device integration, precise timing of sound and graphic events, and integrated tools for scientific visualization.

The general framework of MINT (Figure 3) consists of modular subsystems connected together by a lightweight scheduler and event passing mechanism. Subsystem libraries are conceived for real time cluster rendering, graphical user interfaces, video streaming, sound synthesis, networking, computer vision (e.g., tracking, segmentation), scientific visualization (e.g., surface extraction, plotting), and database interactions. These modules represent the basic tools needed by each discipline, and may be separable or brought together into a single application. MINT is thus conceived as a system where collaborators from different fields can work together, with familiar tools, on integrated projects.

While we expect MINT to be used broadly by scientific and artistic communities, our practical efforts have focused on supporting collaboration with the Allosphere as a primary test environment. To that end, one of the key development areas of MINT is automatic detection and

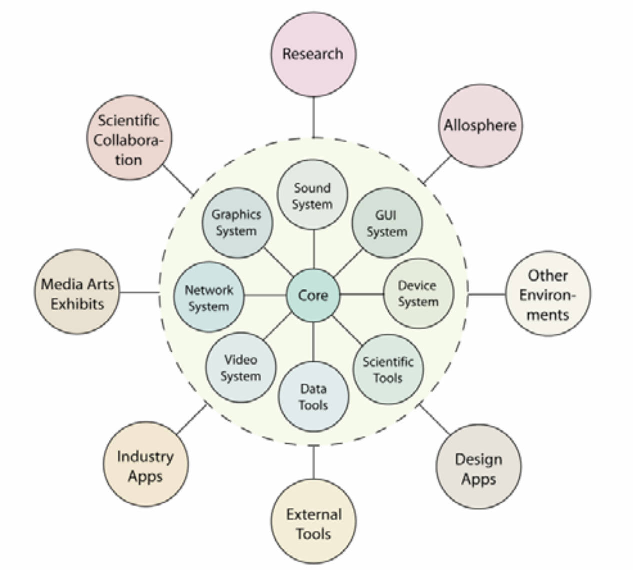

Figure 3. The MINT software architecture

configuration of cluster rendering networks. Unlike other tools in this space (such as Chromium, VR Juggler, and OpenSG), MINT automatically scans, connects and creates windows on available render servers. In addition, rendering is designed to support both an event-based client-server model and a distributed scene graph model to allow for several models of user development. With this, we intend to provide a seamless graphical framework and API for collaborative research projects.

One sample application of MINT is the use of the Allosphere as a gateway for novel manipulations of research data. The stereoscopic interaction of 3D data in CAVE environments has been well researched. However, with the combination of a generalized device interface, sound and rendering subsystems in a single framework, MINT allows for unique manipulations of data. For example, multiple 3D infrared pointers could be used to pull at two points in a nanotech simulation, while simultaneously sonifying and viewing the results in the stereoscopic clustered display environment of the Allosphere. The MINT network system currently allows many-to-many networks, with future designs to permit both multiple machine input (large scale data) in addition to multiple machine output.

Another example using MINT is procedural, real-time cluster rendering of dense 3D scenes in which each machine in the network takes on rendering tasks of its own display, but using distributed procedural events instead of the Chromium-style distribution of OpenGL primitives, Leveraging the power of modern GPUs, such a system could provide orders of magnitude increase in the computational resources available to single simulations.

MINT aims to provide a seamless, easy-to-use framework for collaborative research. To that end, MINT has adopted an incremental API, similar to the model used by GameX (Hoetzlein and Schwartz 2005), allowing novice developers access to methods with default high-level behavior which may be customized by resorting to the full API. One of the most significant barriers to interdisciplinary collaboration on software projects is the basic groundwork needed to create a unifying framework. MINT takes care of the application loop, event passing, and graphics asset management (running on Windows, Mac and Linux), yet remains a modular C++ library, so that developers can focus their attention on project development.

The core infrastructure (including event passing, scheduling, and memory management), a networking subsystem, and autonomous window configuration for networked displays with MINT is complete. Our efforts are currently focused on implementing real time cluster rendering modules for both OpenGL and DirectX.

InViTe. As a next layer on top of the local multimedia rendering infrastructure provided by MINT, we provide video-based telecollaboration services as part of our Interactive Video Teleconferencing system called InViTe. Our goal is to provide teleconferencing services that will not be restricted in use to only one platform or one style of physical interaction, but instead scale to the available input and output platforms. At the same time we wish to provide as much information as possible to all users, while maintaining the highest level of presence and copresence possible, given each participant's interaction devices. That is, we wish to allow users with devices such as cellphones and desktop displays to work alongside users with HMDs and CAVEs, and all users should have as immersive and engaging a representation of the meeting space as possible.

Our approach is rooted in the following four main concepts:

- *2D Video*: Leveraging user familiarity with traditional 2D videos, we use video streams as the main medium of exchange, which the participants can augment with multimedia data and directly interact with.
- *Augmentations*: In the style of Augmented Reality, we overlay 3D computer graphics on top of the videos, representing both meeting content and annotation/communication tools.
- *Platform Scalability*: 3D-augmented video streams can be viewed and interacted with on a wide variety of computational platforms ranging from special purpose immersive environments to simple mobile phone platforms.
- *Separation of Remote Spaces*: Groups of remote collaboration partners maintain separate meeting spaces, each one accessible to all participating parties. We decided against one overall virtual shared space in order to keep the meeting scalable and the physical arrangement of local meeting spaces flexible, while still enabling all parties to understand and navigate the involved remote spaces.

It should be noted that the central ideas of InViTe are largely independent of the underlying system implementation. At a systems level there are two main components to the InViTe system: a distributed scene graph and a hierarchical video server architecture.

The distributable scene graph layer was designed for utmost flexibility. Virtual data in the invite system is managed and distributed in hierarchical scenegraph structures. Because of the original demands of the InViTe project our implementation was originally designed to work well with clusters of computers on a high bandwidth low latency intranet, while the computers in each cluster would have high latency connections with variable bandwidth connecting to other clusters and computers.

Updates or requests for data on a remote cluster first travel through a local server. The server then (possibly filters and) transfers these messages to the remote server where they are processed. We chose this method as it allows for flexibility in the amount of data transferred between clusters. Often the local server will be able to operate as a filter for messages or requests, eliminating the useless transfer of data over the larger network.

Updates are sent from the updating client to the client's local server where they will be distributed to any server the local server knows. The servers need not interact along a fully connected graph consisting of all the servers in the system. However, due to issues of lag surfacing with sparser distribution schemas in our simulations and first international test runs, this setup is the recommended layout until we implement more intelligent QoS support.

Video data is distributed along the same paths as the virtual data with video servers acting as local caches for video material sent over low-bandwidth connections.

An initial description of InViTe's architecture and some interactive client interfaces for it can be found in (Höllerer and Coffin, 2006) and (Coffin and Höllerer 2007).

Soundium. Soundium is a development and real-time presentation environment that allows for exploration of new ideas in the domain of user-interaction, computer-assisted multimedia content creation, and real-time multimedia processing. It originally evolved as an expressive instrument for live visuals performance (VJing) (Müller *et al.* 2008). Over time, the system was generalized and was used as a generic multimedia development tool.

The aspects of real-time media processing and media content interaction separate Soundium into two basic layers. A real-time engine employs a global processing graph (Müller *et al.* 2006a). The graph unifies subgraphs of various entities such as data flow graphs for audio and video processing, or scene graphs for 3D graphics. Nodes of these subgraphs can directly be interconnected, which allows for a tight coupling across different modalities, for instance from audio to graphics.

On the interaction level, a central data structure called the Design Tree, allows for exploration and navigation in collections of content. In addition, it keeps a rich history of all modifications applied to content. Explorative search and history-keeping are both attributes considered as crucial for creativity support tools (Shneiderman 2007). The core idea of the Design Tree is to extend the well-known application paradigm of undo and redo. In contrast to standard undo/redo, we do not invalidate the redo path, but create a "branch" at the current state; consequently, a tree structure emerges. In Soundium, each node in the design tree represents a particular configuration of a processing graph, and the tree's edges constitute changes to the graph. The design tree thus automatically organizes a potentially large design space (with thousands of parameters), and allows for navigation and exploration therein.

In practice, the Design Tree is applied to support the artistic workflow from early idea to the actual realization of a project. In the case of live visuals performance, the tree is used during composition phase in order to create and modify designs, as well as during the live performance, where designs are activated and expressively manipulated. Organization of a vast design space is certainly desirable not only for artistic projects, but for many other domains, such as computer-aided design or scientific visualization.

Besides its use in live visuals performance, we have used Soundium to explore collaborative creativity that employs mobile devices (such as cell phones) in a public space. The artistic project called "Rip my Disk" (Müller *et al.* 2006b) brought interaction to the dance floor: the audience can provide imagery for video projects via Bluetooth. The space was divided into several Bluetooth zones (by limiting the range of the receivers), and the provided content followed its creator when moving around. In addition, the audience could use the infrared emitting diode (used for IrDA communication) to interactively "paint" on the projected screen. While an IR camera recorded the movements, an IrDA receiver exploited security holes and downloaded content from the cell phone – hence the name "Rip my Disk."

The artistic goals of this project were (1) to find out how individuals deal with exposing personal content in a public space, and (2) to see if the published content would engender some sort of communication. For (1), the result was similar to what has been observed elsewhere, e.g., in web-based social networks: many people freely exhibited personal content, but at the same time controlled what to publish and what to hide. For (2), we observed that individuals started to use their cell phones as "expressive instruments" in order to respond to content of others. Particularly popular were the interactive painting features. However we found that the collaborative behavior is hard to anticipate, and it is notably difficult to foresee how a certain device as actually used (or misused).

Applications

We put the abovementioned hardware and software technologies to use in several application scenarios that all rely on the concept of creative collaboration. As an initial set of application drivers, we consider general gesture-based human-computer interaction, media-supported interactive education, collaborative design, both industrial and artistic, and exploration in science, with research partners in molecular dynamics, neuroscience, nanosystems, and the geosciences.

Ensemble-style HCI. Musical performance provides an elaborate research test bed of subtle and complex gesture interaction among the various members performing in a group. The interaction among performers with their special devices, musical instruments, serves as an interesting design model for multi-user interaction devices where each researcher has a specific device and is generating and processing information among multiple users in the context of a single data set, the musical score. This research proposes to develop new human-computer interfaces for controlling knowledge dissemination based on the way that humans interact in a musical ensemble performance, aiming to pioneer new interfaces that will allow us to interact with electronic content through gestural control.

We postulate that creative artistic design and use of sensor-based human input in computing environments will be a key element in defining next-generation research and teaching tools, and we foster such a creative design process through experimental exploration. We leverage our various visualization environments, the Allosphere and the Fogscreen, as well as more traditional flat panel displays of various sizes. Our goal is to develop next-generation "musical ensemble-style" user interfaces for controlling artistic performances, interactive scientific explorations, and instructional performances on large electronic stages, such as select full-dome planetariums, and novel devices as the Fogscreen. We anticipate this to lead to major contributions for teaching in electronic classrooms, in which the walls will be covered by large-scale interactive displays, as well as unique office and studio spaces that will need novel interactive display settings.

Classroom of the Future. Inspired by the way novice users collaboratively explore our multimodal digital media setups, we are developing our own vision of the digital classroom of the future. We follow a model of the classroom as a digital stage, on which the educational activities unfold, either driven or moderated by the teacher. The stage is not intended as a substitute for the blackboard as the sole locality of focus. Rather, we are interested in using the entire classroom space as the digital stage. The physical setups could vary from a *theatre in the round* style to settings that include the audience, to auditorium-style stages, on which students control content from the distance of traditional classroom seating arrangements, to remote stages that incorporate tele-collaboration solutions (Coffin *et al.* 2008).

A stage model for digital classrooms has several advantages:

- It is very flexible and compatible with many different teaching styles.
- It can focus the attention of the students on a common goal and part of the stage, while providing more context than a traditional blackboard or whiteboard.
- It is very participatory in nature, giving every student the opportunity to contribute to the "stage play."
- It can be supported by technology in a way that keeps the focus on the content and the social interactions among the participants, and not the technology.
- Because of the positive largely positive and artistic connotations of the stage and performance concept, it is a good candidate model for engaging students and stimulating collaborative creativity.

Collaborative Design. In synch with the previous application domain, one of the larger themes of our work is stimulating creativity in groups of students. The field of engineering design has systematically focused on creativity as a mechanism for stimulating innovative products. Innovative products and systems can provide a significant competitive advantage and new market opportunities for companies. Global competition has only increased the need for more innovative products. Researchers have examined the characteristics and process of creativity, and design practitioners and researchers alike have developed methods for fostering creativity in engineering and product development. These methods have focused largely on guidelines for eliciting creative ideas from individuals and teams; less attention has been paid to the role of the physical environment on encouraging creativity. In our design-oriented research, we are considering ways to enhance and stimulate creativity in the context of non-traditional, immersive physical environments with implications beyond the classroom. The Allosphere provides a unique collaborative laboratory for examining two issues in ways not possible before: 1) the role of physical environments in stimulating creativity on individual creativity, and 2) the role of physical environments on creativity in interdisciplinary teams.

Scientific Exploration. Together with several scientific collaborators, we are planning a variety of collaborative scientific data exploration and visualization projects, leveraging the abovementioned technologies.

Biochemists need richer, more powerful tools for interactive visualization of molecular dynamics simulations. These should enable real-time collaboration, dynamic probing of binding modes, and the design of improved inhibitor peptides.

With nanotechnology, researchers are developing novel devices by altering the way in which the matter in those devices is structured at the nanoscale, producing advances of orders of magnitude in many fields such as structural materials, electronics, optoelectronics, biotech, and medicine. Currently, however, nanotech researchers do not have access to practical computer simulations to predict many of the physical properties of such devices, so their design and fabrication process remains mostly trial and error.

Visualization of complex time-based neuroscience data from fMRI experiments for brain imaging is limited by current tools. We will collaborate with neuroscientists to leverage the Allosphere visualization and sonification possibilities to provide a more powerful cross-modality instrument for fMRI exploration.

Geoscience applications will initially consist of two projects. The first will be a conversion of the GoogleEarth API to allow viewing of global data sets on an inverted sphere projected on the interior of the Allosphere. The Google API allows input and co-registration of image data; global imagery from NASA (of global circulation models, global temperature, sea level rise, etc.) will be integrated for viewing, with the usual user navigation. Secondly, a campus data base will be assembled by combining the GIS data from the UCSB campus facilities management department with a LIDAR height field, a 4 inch resolution air photo and live feeds from various webcams scattered around campus.

Summary

We have presented a vision and initial steps towards supporting rich data exploration and collaboration in multiple computing environments. Our goal is to provide an array of experiences that lend different perspectives and insights to scientific problems and artistic expression. Our software infrastructure will support a range of computing environments, including the Allosphere and the interactive Fogscreen, and enable various applications to leverage these environments for new ways of visualizing and working with complex data.

Initial implementations of various components and experiments in Allosphere and Fogscreen environments are encouraging, showing great promise for compelling user experiences for collaborative interaction and exploration.

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