The Representation and Navigation of Complex Data

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In this paper we are attempting to address issues related to perception and consciousness deriving from the management of overwhelming data, utilizing artistic/design and sound production practices in virtual reality/environments.
In the ordinary flow of day to day activities the self descriptive, self-reflexive, and recursive processes of data collection reveal themselves. These pairs are not encountered as binary oppositions in conflict, but in a continual management of data transformation. We converge with our own solutions—and the development of technological tools—and give birth to new scientific tools as well as intuitively artistically generated tools, literally and figuratively.
….. a system prototype - 'Vineta' - has been developed at the IPP allowing navigation through scientific and technical data without typing and revising keyword-based queries. The chosen approach to visualizing documents and terms in navigational retrieval includes the representation of documents and terms as graphical objects, and dynamic positioning of these objects in a 3-dimensional virtual navigation space. Users can navigate through this virtual space examining individual documents and clusters of documents at various levels of detail.

Keywords: *Data visualization / representation, virtual reality, wearable computers, interaction, sound, architecture, overwhelming data management, immersion, search, graphs, drawing algorithms, communications, collapsible modular spaces, scatterplot, sound spatialization, mixed / augmented reality*

Introduction

Overwhelming data is clogging up all aspects of productive management and organization, occupying increasingly enormous amount of space. The convergence of disciplines triggers changes in how we think about possible productive and creative solutions, affecting context and meaning in virtual practices. Thus this project brings together a computer scientist, a designer of wearable computers and performance artist specializing in virtual environments and cyborgs, a graphic designer, an architect and a sound designer who wish to investigate the representation and navigation of complex data systems both visually, aurally and from a performative aspect in the realization of an immersive virtual environment dedicated to the search of such data.

Exposition

Information Visualization is a growing research domain with several important annual international conferences and journals. Research groups from various universities are active on this domain. Several companies such as Google, Amazon and SmartMoney are developing tools to enable their users to explore their large datasets, thus improving customer experience. Information Visualization traditionally targets to abstract formations from seemingly unstructured data. An important example of this approach is graph drawing. Until recently the level of clarity and aesthetics of how the structure of a given graph can be drawn algorithmically has been the predominant driving force behind the development of various sophisticated graph drawing algorithms.

Using spatially organized multi-user virtual environments and establish connection between information visualization and virtual environments is a recent approach. One example is the Starlight Information Visualization System from Pacific Northwest National Laboratory, which integrates information modeling and management functionality with a visualization oriented user interface. Another hot topic is the self organizing maps with the look and feel of an ordinary geographic map, which lead to several commercial applications such as ILOG, Hivegroup, Grokker.

In addition, research groups are working to incorporate the dynamics of data (growth, evolution and development) into information visualization systems. In this project we will build up on existing work combination of virtual environments and information visualization by extending it by three new approaches:

- Employing wearable and mobile interfaces to navigate and get immersed into data visualization. Most if not all of the existing research is dealing with desktop applications. However with the advent of mobile computing and communications a major challenge is coping with overwhelming data in a mobile context.
- Interdisciplinary perspective. All the current research is conducted from an engineering point of view. However interaction with large data is not only an engineering problem but a design one.
- Incorporating sound. Sound is an unexplored field for information visualization field. Although we obtain more than 70% of information through our eyes, sound contributes up to 80% to get immersed into a virtual environment. However current research did not take advantage of sound mainly due to lack of collaboration.

We are engaged in a process of generating meaning through cybernetically inscribed human gestures by identifying and navigating the visual representation of data clusters. A gestural human sign language and human postures is being exploited utilizing additional possibilities through the use of advanced technologies as medium for inscription. The composed / collected gestures and movement material become a source of intention that relates to itself; its communicating environment becomes a visualization of the self-reflexivity inherent in the workings of both the vast data and consciousness. The solution is in between the worlds of data management / shapes / visuals and the source language as it transitions and transforms into the domain of visible thought.

Methodologies include the use of large scale multi-dimensional data management, and visual data representation systems, the combined seductive power and agency of technologically charged interactive systems, wearable devices / computers, and 'virtual reality'. They are fed through direct gestural human intervention within a remembering knowledge space / system by way of accumulation. Most notably, these devices are being made with the use of smart intelligent new fabrics and sensory sensitive elements that are always on / with the user / interactor, and into which the user can always enter commands while walking in and around the electronically charged space.

The working hypothesis for this aim is that a vo-

cabulary of direct gestural and electronically generated sound expressions of creative intentions can be recognized, so that a choreographed set of gestures/ movement can map the experiential body state of each gesture to corresponding system actions. Most notably, these devices are being made with the use of smart intelligent new fabrics that are always with the user / interactor, and into which the user can always enter commands while walking in and around the space.

Design

Wearable Devices

My wearable computers and interactive devices are often subsumed into my own personal space, designed to be placed on my body in a desired way / place where as the primary performer I can activate them at wheel, and as needed. This sensory phenomenon includes additional operational command systems and interactional constancy that facilitates performance augmentation in real time. They are always on and always accessible. As such these devices have become an extension of myself, well integrated, affected by my own way of moving, gesturing, posturing, thus allowing me to operate in and around a communications area (performance or alternative performance space) that is receptive and directly responsive to my physical commands.

Based on operational and performance experience, I think of my wearable computers and Interactive systems as much more than just wristwatches, jewelry devices, regular eyeglasses, different types of floor pads, and or motion tracking devices. They posses the full functionality of being a computer, a wireless communication system, and by being fully interactive. Since they are also inextricably intertwined with myself as the wearer they contribute greatly to augmenting my operational abilities. Continuous research facilitates on going development of these systems operational sensory attributes so they can (in addition) fully function as a medium for inscription. They accept/detect human moves, morphing, scaling, making color changes, and adding new dimensions of expressivities and meaning to performance.

Our artistic practices are converging literally and figuratively in this zone of physical and technologically generated virtual worlds. Our exploration flutters around these "subversive" multiple sensory wireless / wearable systems and wireless video cameras for multiple purposes depending on subjects and tasks to be performed. Our intention is to utilize and integrate these digital technologies/devices for operation through pedestrian movement gestures, postures and design process in an environment used on a daily bases. We are currently investigating aspects related to large (difficult to manage) data gathering, processing, and ultimately data clustering. The purpose is to generate sound production, art design/images, architectural non-habitable structures, virtual worlds, and dance performance in this given space. Particular emphasis is placed on the real and the virtual, boundary, and perceived boundary, how it will affect the way we communicate, how we can alter the mind, zone of awareness, feelings, and the walking consciousness.

Space / Architecture

The architecture consists of a retractable / collapsible modular space construction that will grow or pull itself back as you move within the data. As for the data display systems, there are numerous 2 sided scatterplots, on which clusters of data will be shown based upon the specifics of the search. The user will be at liberty to add on, remove or temporarily collapse these structures. Furthermore, each set of outward facing scatterplots has a central hub, both the inner as well as outer of which can be used to project data content, i.e. charts, web pages, text, etc. and the inside of which can be used for selected data storage. Selecting data will reveal embedded clusters / scatterplots, i.e. layers which can be accessed by means of a spatial / perceptual shift achieved by enriched zooming.

This fractal-like system can be navigated with

the aid of wearable computers and the navigation, eased by a remote control device, will take the user into deeper data layers which will materialize on the primary scatterplot as smaller, embedded scatterplots, which are zoomable, and in turn reveal further embedded data layers, i.e. scatterplots. The idea behind this is, we provide only the necessary portion of space needed for a particular type of information and the rest of the needless space disappears momentarily in order to avoid confusion due to excessive display of background detail. This is like the "visibility" option in some computer games that allows you to set the distance of objects to be seen by the user. Displaying only the necessary portion of space needed at a particular time will also help us saving computer processing time.

Icons and Palettes

The clusters of data will have distinct color schemes for ease of identification. Data will be represented as cubes since cubes are efficient in terms of stacking and grid formation. Different types of data (i.e. live, static, embedded, statistical) will have different patterned cubes assigned for easy recognition. Range of hues, as well as transparency values will be used to represent different clusters of data. Luminosity will be employed to visualize relevance to query. These patterns can be changed by using pop-up menus accessed by remote control. Pop-up menus will be provided for data search and location identification as well.

The remote control, to be used in conjunction with the wearable computer, will facilitate data queries, selection and arranging of data and the accessing of virtual screens and palettes in the immersible environment.

Sound Design

Representation of complex data with use of sound analysis enables us to facilitate problematic of clustered visual recognition cues. Different aspects of sound can be utilized for developing alternative parameters to span a detailed analysis in a complex system. Wide use of home theater systems, created a mass of well trained ears, which are capable of differentiating various properties of a sound source with respect to its integral elements such as intensity, fidelity and positioning. Positioning of a sound object in a physical 3D acoustic space with use of various combinations of allocated speaker locations can contribute to suffix a new dimension for complex data. On a basic level, frequency analysis of an ear can be potential for representation of information with using scales of tones such as bass, mid, low. In addition, progressive ear training would enhance the skill of a person to dedicate more data representation with sonic cues.

Programming the environment

The key issues and concepts from technology point of view can be studied as follows:

- Estimation and prediction of user's state: The proposed system should determine the context of the user and especially the dynamics of the change in the context. Using this information the system can modify the aural and visual renderings.
- Improving perception of virtual reality continuum: One of the main issues in virtual reality is lack of natural perception of time and 3D space. By introducing a synthetic delay between instantaneous actions into the simulation system we can achieve this delay. The architecture and scales of the objects in a virtual environment do not necessarily relate to the real world. It can be difficult to estimate actual size and distance. Thus all the transformations in a VE must follow consistent rules to deliver a consistent 3D experience for the user.
- Enhanced interaction techniques: Breaking the traditional interaction techniques requires investigation of novel techniques such as: recombinant systems, remembrance recognition systems, optical tracking, gesture and posture recognition and tracking. All or a set of these technologies will enable a natural interaction between the system and the user.

An interesting research area is the interaction by using one's own body as interface. The limiting factors of current interfaces and hardware can be augmented by the introduction of human gestures / movement that can be used for navigational and interactive purposes through the aid of wearable computers: Current interaction techniques limit human interaction with data, e.g. we currently use only mouse and keyboard to interact with a computer. Both devices allow only a few Degrees of Freedom (DOF) to interact with (mouse 2 DOF (x,y)). However the human hand and arm are capable of more than 50 DOF, which means that we can convey / modify much more expression / gesture / feelings with our hands than a mouse and keyboard. If we think about direct manipulation of objects, using a "mixed / augmented reality" setup it is more natural than the mouse / keyboard setup. Users can interact with the real world using objects in space. This is a realistic / doable scenario with current technology with few limitations such as number of objects you can interact with. However this solution will might not be general enough for our purposes. And it can limit the users DOF for expression/interaction.

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