ISEA2009, the 15th International Symposium on Electronic Art (2009)

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Human Trace

Paper id: 211.

Keywords: Immersive, Visualisation, Data, Ecologies, techno-ethnography, mobile.

Abstract.

“Idly, he wondered what these geometric forms really represented - he knew that only a few seconds earlier they had constituted an immediately familiar part of his everyday existence - but however he rearranged them spatially in his mind, or sought their associations, they still remained a random assembly of geometric forms.” (Ballard, JG)

This paper explores the development of visualisation systems to enable high-resolution, real-time rendering and manipulation of complex data sets for domed augmented virtual environments (DAVEs). This activity is coupled with the use of embedded and mobile technologies to collect environmental and individual, collective ecological footprints through a techno-ethongraphic process (Operating Systems). The focus of this project will be to trace the ecological and social impact of human activity. However, the research offers a broad range of solutions for the visualisation of any appropriately formatted data set.

Human Trace represents a collection of synergetic projects that augments and extends the current visualisation facilities located in the Immersive Vision Theatre (IVT), a full dome environment located in the University of Plymouth. Whilst the IVT is capable of high-resolution visualisations through its dual projectors, the focus on FullDome environments has traditionally been on the playback of pre-rendered ‘shows’.

Human Trace is developing the platform as an open design tool for real-time 3D rendering of dynamic data sets. With the necessary increase in sophisticated data visualisations (scientific, economic, social and cultural data) comes a concern for an apparent parallel decrease in visual literacy as scientists and non-scientists alike struggle to decipher the mass of content. This is particularly apparent with ‘Climate Change’ initiatives where attempts to communicate science through a variety data modelling and visualisation techniques has lead to confusion and disagreement in the public/media arena (Niepold, F. Herring, D. McConville, D. 2007).

The ambition for these projects is to put data, an abstract and invisible material, to effective use by making it manifest and tangible through a process of reification its metaphorical and haptic potential are powerful tools for transformation. These activities bring together ‘Renaissance Teams” drawn from a variety of disciplines, underpinning creative interventions with cognitive psychology, scientific data visualisation, Environmental and Computer Science. They create a rich dialogue between these disciplines through a dynamic interaction with rich interactive media forms, and generate coherent and synergetic research methods.

Data Immersion.

“The consequences of various world plans could be computed and projected, using the accumulated history-long inventory of economic, demographic, and sociological data. All the world would be dynamically viewable and picturable and radioable to all the world, so that common consideration in a most educated manner of all world problems by all world people would become a practical event.” (R. Buckminster Fuller, 1962)

The project engages with fundamental issues that underpin assumptions about technologically-mediated immersive environments and their application for enhancing experience. These assumptions are unproven and under-researched but are at the heart of many commercial and public sector capital and digital media initiatives. Immersivity is the extent to which immersion – or sensory saturation - occurs and is an inherent or designed characteristic of both personal and shared environments. Immersion is thought to invoke ‘presence’ or ‘flow’ – terms used in different disciplines to describe, respectively, the transient or continued perceptual state in which the participant recognises or believes themselves to be in an unmediated environment, and adopts thoughts and behaviours accordingly.

Technological mediation is used to invoke immersion, presence and flow in gaming, where the intention is to entertain, and in simulator-based training, where the intention is to ingrain an unconscious psychomotor response to stimuli. Success in these uses suggests a powerful role for immersivity in the conscious, cognitive and affective engagement. The aspiration to change behaviour through immersion in data manifestations is a motivating factor in these activities. Immersion is the biophysical process of sensory saturation and is thought to invoke ‘presence’, a perceptual state in which participants recognise themselves to be in an unmediated environment and adopt thoughts and behaviours accordingly.

The limited empirical evidence available suggests that immersive environments allow participants to adopt an egocentric view (in which one’s own body is the spatial frame of reference). Abstraction and active testing can be invoked by interactivity; in immersive environments interactivity may include ‘vection’, the perception of self-motion whilst stationary. Further, media theory suggests that immersivity, presence and content are bound together inextricably, producing heightened perceptual states conducive to the absorption of unfamiliar concepts. Within this context the coupling of data visualisation technologies with immersive environments may afford enhanced understanding and behaviour change.

Data Source.

The data collected by the Human Trace generates a dynamic mirror image of our world, reflecting, in sharp contrast and high resolution, our biological, ecological and social activities. Reluctantly, we are becoming aware of the data shadows that cloud the periphery of our existence, as if through a glass darkly. The reluctance is, to some extent, the result of the fear we feel when we catch a glimpse of this data/mirror world out of the corner of our eye, somewhere there is an attic in which stands a large ugly data portrait. Reified its metaphorical and haptic potential are powerful tools for transformation. The incorporation of real-time four-dimensional data into immersive environments may provide a reflexive space for participants to better understand their involvement in the generation of the content they are viewing.

The publication of complex data sets, whether in real time, pre-processed or archived forms, as a raw resource at a variety of resolutions is becoming a standard practice within many disciplines. There are

established methods for sampling and transmitting discreet snapshots of data in an isochronous manner, as distinct from asynchronous, with varying degrees of latency. Latency, and its value are completely context dependant. 24 Hours BMS data, a one-hour-old satellite image of cloud cover, and sub 200ms mouse movements, are considered 'real-time' within their respective domains. Many applications within Human-Computer interaction, Computer-Human interaction and Human-Human communication require low-latency isochronous data - dealing as they do with perceptually tolerable latencies.

Data Formatting: Human Trace focuses on ESRI (GIS), GRIB (meteorological), GML (OS), KML and WMS (both service oriented architectures rather than straight file formats) formats. The ubiquity of XML based formats is being established within many disciplines, this is already true of GML, and KML - but can be seen in disciplines as diverse as Neuro-science (NeuroML), Chemistry (CML) and initiatives by Usman Haque to establish an Urban XML. Feeds distributed by Operating-Systems (see below) are also based on standard XML and RSS formatting. XML has advantages such as hierarchical structure, human readability and well-proven paths for parsing and generation.

Along with latency there are critical issues of resolution. The scale, resolution and granularity are as important for comprehension as complexity. Understanding a feed from a water meter is as problematic as understanding levels of precipitation within a region. Locating data in experience is a critical as revealing it through experience. To tackle this a series of Operating Systems are being developed to ground data experiences.

Data Feed.

“In short, the universe is but a watch on a larger scale; all its motions depending on determined laws and the mutual relation of its parts. Confess the truth, have you not hitherto entertained a more exalted idea of the works of nature? Have you not considered them with more veneration than they deserve? I have known some people esteem them less as their knowledge encreaed. For my part, said she, I contemplate the universe with more awful delight now I find that such wonderful order is produced by principles so simple.” (Fontenelle, 1803)

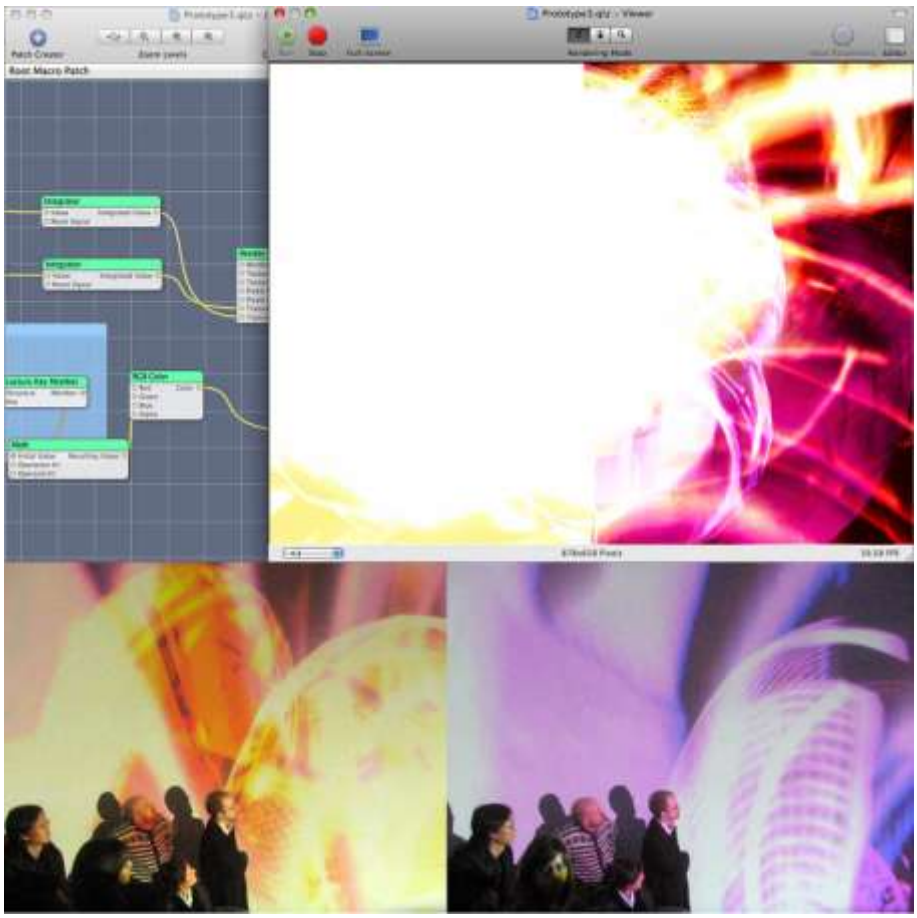

Figure 1: Architectural Ecologies Quartz Composer Data Reader: A trans-disciplinary research workshop.

A critical component of the Human Trace is the alternative data collection initiated through a range of ‘Operating Systems’ which dynamically manifest ‘data’ as experience and extend human perception. Data collected or generated is parsed and published through a range of flexible tools (flash, Max MSP, Processing, Java, etc), feeds (xml, rss) and web 2.0 streams, such as Twitter and Facebook, which allow artists, engineers and scientists to develop visualisations, sonifications (music) and interactive projects.

Arch-OS (www.arch-os.com) uses embedded technologies to capture audio-visual and raw digital data through a variety of sources which include; the 'Building Management System (BMS), digital networks, social interactions, ambient noise levels, environmental changes. This dynamic data is then manipulated and replayed through audio-visual projection systems. By making the invisible and temporal aspects of a building tangible. The i-500 (www.i-500.org), a public art commission for Curtin University’s new Resources and Chemistry Research and Education Buildings, draws on the Arch-OS experience. Working in close collaboration with Woods Bagot Architects the i-500 project visualises scientific research as an integral part of the architectural environment. Nested at the heart physical building the i-500 enables a zone of contemplation and reflection.

S-OS. Social Operating System for Plymouth (www.s-os.org) provides a new and more meaningful ‘algorithm’ for modelling ‘Social Exchange’ and proposes a more effective ‘measure’ for ‘Quality of Life’ indices suggesting happiness might not lie at the end of a bell curve and that true love can’t be found in a slice of a pie chart.

Co-OS is a collaborative Operating System, a ‘Reciprocity Engine’, is a cultural brokerage and social networking project which facilitates a radical new network model of collaborative creative production. The key innovation is the coupling of an open Web 2.0 online network environment with a modified LETS (Local Exchange Trading System) scheme.

Eco-OS further develops the sensor model embedded in the Arch-OS system through the distribution sensor devices - Ecoids. Ecoids can be distributed through an environment (work place, domestic, urban or rural) and connected through the formation of Wireless Sensor Networks (WNS) that enable the coverage of an extensive territory.

Mob-OS explores the intimate relationship between people and their mobile communication technologies, enabling the collection, annotation and reading of data from numerous environments.

Bio-OS: Bio-OS takes a more granular view of the social environment, focusing at a resolution of the individual. By exploring manifestations of physical, psychological and behavioural aspects, Bio-OS takes a holistic, multisensory systems view of an entity to build reflexive data models of a body over time.

Data Consumption.

At the core of these developments is the Immersive Vision Theatre, a transdisciplinary instrument for the manifestation of material, immaterial and imaginary worlds. The ‘Full Dome’ architecture houses two powerful high-resolution (fish-eye) projectors and a spatialised audio system. A number of initiatives are being investigated to enable the rendering of real-world data into forms suitable for projection into immersive domed environments. Outside of WorldWind (NCSA) and Uniview (SCISS) there are few software applications specifically designed to solve this problem, even fewer applications exist to take real-time, real-world data feeds and visualise these in a suitable manner for projection in a dome. Even as new game engine technologies open up opportunities for dome environments, the problem presents a series of complex challenges across multiple domains. Regardless of the strategy used, solutions will be based on a number of underlying technologies.

These include: the Scenegraph, practically all 3D technologies that are concerned with drawing more than mere primitives have a notion of a scenegraph where a hierarchical description of the objects to be displayed; DirectX and OpenGL are perhaps the most ubiquitous of 3D technology for 3D rendering is Z-Buffer or 'scanline' , as implemented by OpenGL or DirectX. OpenGL and DirectX are standards that enable GPU (Graphical Processing Unit) manufacturers to create bespoke acceleration architectures that can be driven by a standard API.

However, neither OpenGL nor DirectX have any notion of a 180 degree fisheye camera, an essential requirement for dome rendering. There are a number of techniques for simulating a fisheye, the most common uses (up to) six cameras in a cubic arrangement stitched seamlessly onto the surface of a sphere, with yet another camera pointed at it. It can be seen from this that rendering for a domed display incurs in the order of a 7x penalty. Where a standard OpenGL/DirectX application would use one render pass – a domed application needs 7. Another approach which has been pioneered by The Elumenati is to use a GPU shader to improve performance. Modern GPUs have a pipeline that can be programmed using small pieces of code in languages specific to the GPU.

Whilst most OpenGL/DirectX applications are written in C++, it is becoming more common to write applications in a 3rd party, higher level library. Examples of libraries such as this are Panda3D (Carnegie Mellon/Disney), OpenSceneGraph and OpenSG. 5th generation visual programming environments such as QuartzComposer (figure 1), Max/MSP, VVVV and PureData also offer possibilities.

Additional explorations are being made using: Graphics Clustering, splitting of complex processes into smaller tasks that can be distributed among multiple clustered computer nodes; Real Time Raytracing: ordinarily raytracing is not an approach that is applied to high frame rate real-time 3D visualisations, but such a granular problem lends itself to distributed or clustered topology.

These rendering issues are intrinsically linked to media transport protocols. As the Internet is the medium and transport layer for many of the data streams, choices in protocols and data formats will be governed by those implemented on the Internet. These include: FibreChannel, Infiniband, proprietary fibre-optic based interconnection systems; CAT 5/6 'Twisted Pair' Ethernet (for speeds up to 1Gb/s and 10Gb/s); TCP/IP, UDP, RTP, [HTTP, RTSP] SIP, UDP, RTP/RTSP. Eco-OS also uses XBee 802.15.4 and extended-range XBee-PRO 802.15.4 which use IEEE 802.15.4 networking protocol for fast point-to-multipoint or peer-to-peer networking and mesh networks.

Summary

Human Trace is concerned with the development of a flexible and open visualisation and data gathering system for gathering and rendering complex data sets from a variety of sources. In doing so it brings together the interface design and presence research being undertaken within the IVT with these technologies in an attempt to provide an open source visualization toolkit which critically engages visualization community in a dialogue about information literacy. Essentially the projects blend the psychology of immersivity, methods for gathering data on (intrinsically linked) human and environmental activity, the formatting of this data and its re-emergence through a range of technologies for consumption through human experience.

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