Chapter 11
Cultural Data Sculpting: Omnidirectional Visualization for Cultural Datasets

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Abstract This chapter presents five research projects currently underway to develop new omnispatial, omnidirectional visualization strategies for the collaborative interrogation of large-scale heterogeneous cultural datasets using the world's' first 360°-degree stereoscopic visualization environment (Advanced Visualization and Interaction Environment – AVIE). The AVIE system enables visualization modalities through full body immersion, stereoscopy, spatialized sound and camera-based tracking. The research integrates work by a group of international investigators in virtual environment design, immersive interactivity, information visualization, museology, archaeology, visual analytics and computational linguistics. The work is being implemented at the newly established research facility, City University's Applied Laboratory for Interactive Visualization and Embodiment – ALIVE) in association with partners Europeana, Museum Victoria (Melbourne), iCinema Centre, UNSW (Sydney), UC Merced (USA), the Dunhuang Academy, and UC Berkeley (USA). The applications are intended for museum visitors and for humanities researchers. They are: (1) *Data Sculpture Museum*, (2) *ECloud*, (3) *Blue Dots 360* (Tripitaka Koreana), (4) *Rhizome of the Western Han, and* (5) *Pure Land: Inside the Mogao Grottoes at Dunhuang*.

11.1 Introduction

Research into new modalities of visualizing data is essential for the world producing and consuming digital data at unprecedented rates [23, 27, 44]. Existing techniques for interaction design in visual analytics rely upon visual metaphors developed more than a decade ago [28] such as dynamic graphs, charts, maps, and plots. Currently, the interactive, immersive, and collaborative techniques to explore

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large-scale datasets lack adequate experimental development essential for the construction of knowledge in analytic discourse [51]. Recent visualization research remains largely constrained to 2D small-screen based analysis and advances in interactive techniques of "clicking", "dragging," and "rotating" [27, 52]. Furthermore, the number of pixels available to the user remains a critical limiting factor in human cognition of data visualizations [26]. The increasing trend toward research requiring 'unlimited' screen resolution has resulted in the recent growth of gigapixel displays. Visualization systems for large-scale data sets are increasingly focused on effectively representing their many levels of complexity. These include tiled displays such as HIPerSpace at Calit2 [22], and next generation immersive virtual reality systems such as StarCAVE at UC San Diego [10] and Allosphere at UC Santa Barbara [2].

However, in general, the opportunities offered by interactive and 3D technologies for enhanced cognitive exploration and interrogation of high dimensional data still need to be realized within the domain of visual analytics for digital humanities [29]. The five projects described in this chapter take on these core challenges of visual analytics inside the Advanced Visualization and Interaction Environment (AVIE) [1, 45] to provide powerful modalities for an omnispatial/omnidirectional (3D, 360°) exploration of heterogeneous datasets responding to the need for embodied interaction, knowledge-based interfaces, collaboration, cognition, and perception [50]. The projects are developed by the Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), City University, Hong Kong [3]. A framework for 'enhanced human higher cognition' [18] is being developed that extends familiar perceptual models common in visual analytics to facilitate the flow of human reasoning. Immersion in three-dimensionality representing infinite data space is recognized as a pre-requisite for higher consciousness, autopoesis [43]; and promotes nonvertical and lateral thinking [47]. Thus, a combination of algorithmic and human mixed-initiative interaction in an omnispatial environment lies at the core of the collaborative knowledge creation model proposed.

The five projects discussed also leverage the potential inherent in a combination of 'unlimited screen real-estate', ultra-high stereoscopic resolution, and 360° immersion to resolve problems of data occlusion and distribution of large-scale data analysis in networked sequences in order to reveal patterns, hierarchies, and interconnectedness. The omnidirectional interface prioritizes 'users in the loop' in an egocentric model [26]. These projects also expose what it means to have embodied spherical (allocentric) relations to the respective datasets. These hybrid approaches to data representation also allow for the development of sonification strategies to help augment the interpretation of the results. The tactility of data is enhanced in 3D and embodied spaces by attaching audio to its abstract visual elements, and has been well defined by researchers since Chion et al. [7]. Sonification reinforces spatial and temporal relationships between data (e.g. an object's location in 360°/infinite 3D space, and its interactive behavior (for example, see [60]). The multichannel spatial array of the AVIE platform offers opportunities for creating a real-time sonic engine designed specifically to enhance cognitive and perceptual interaction, and immersion in 3D. It also can play a significant role in narrative coherence across the network of relationships evidenced in the datasets.

11.1.1 Advanced Visualization and Interaction Environment

Applied Visualization Interaction Environment (AVIE) is the UNSW iCinema Research Centre's landmark 360° stereoscopic interactive visualization environment space. The updated active stereo projection system together with camera tracking is installed at ALiVE. The base configuration is a cylindrical projection screen 4 m high and 10 m in diameter, a 12-channel stereoscopic projection system and a 14.2 surround sound audio system. AVIE's immersive mixed reality capability articulates an embodied interactive relationship between the viewers and the projected information spaces [1, 45].

11.2 Experimental Projects

The five experimental projects included in this chapter draw upon disciplines such as multimedia analysis, visual analytics, interaction design, embodied cognition, stereographics and immersive display systems, computer graphics, semantics and intelligent search, and computational linguistics. The research also investigates media histories, recombinatory narrative, new media aesthetics, socialization, and presence in situated virtual environments, and the potential for new psychogeography of data terrains. Each work takes place in AVIE system. The datasets used in these five works are:

- *Data Sculpture Museum*: Over 100,000 multimedia-rich heterogeneous museological collections covering arts and sciences derived from the collections of Museum Victoria, Melbourne, and ZKM Centre for Art and Media, Karlsruhe, for general public use in museum contexts.
- *ECloud:* Approx 10,000 objects derived from an internet archive of First World War data.
- *Blue Dots 360*: Chinese Buddhist Canon, Koryo version (Tripitaka Koreana) in classical Chinese, the largest single corpus with 52 million glyphs carved on 83,000 printing blocks in thirteenth century Korea. The digitized Canon contains metadata that links to geospatial positions, contextual images of locations referenced in the text, and to the original rubbings of the wooden blocks. Each character has been abstracted to a 'blue dot' to enable rapid search and pattern visualization ; for scholarly use and interrogation.
- *Rhizome of the Western Han*: Laser-scan archaeological datasets from two tombs, and archeological collections of the Western Han, Xian, China culminating in a metabrowser and interpretive cybermap; for general public use in a museum context.
- *Pure Land*: Laser-scan archaeological dataset and ultra-high resolution photography of CAVE 220, Dunhuang Caves, Gansu Province, China, including 2D and 3D animations, redrawn and recolored cutouts (based on archaeological research) and high resolution magnification; for general public use in a museum context.

11.3 Techniques for Cultural Visualization

11.3.1 Cultural Databases and Visualization

The intersection of key disciplines related to the first three projects in this chapter includes multimedia analysis, visual analytics, and text visualization. An excellent review of the state of the art multimedia analysis and visual analytics appeared in *IEEE Computer Graphics and Applications* [6]. The research projects also respond to core challenges and potentials identified in Visual Analytics [28, 55] and to key emerging technologies for the coming years such as Visual Data Analysis and Gesture Based Computing [25]. Visual Analytics includes the associated fields of Human Perception and Cognition, where 3D technologies and immersive and interactive techniques hold significant potential for enhanced research applications [26]. Computational linguistics is providing many of the analytics tools required for the mining of digital texts (e.g. [37, 52, 54]). The first international workshop for intelligent interfaces to text visualization only recently took place in Hong Kong, 2010 [39]. Most previous work in text visualization has focused on one of two areas: visualizing repetitions and visualizing collocations. The former shows how frequently, and where, particular words are repeated; and the latter describes the characteristics of the linguistic "neighborhood" in which these words occur. Word clouds are a popular visualization technique whereby words are shown in font sizes corresponding to their frequencies in the document. They can also show changes in frequencies of words through time [23], in different organizations [8], and emotions in different geographical locations [19, 21]. The significance of a word also lies in the location at which it occurs. Tools such as *TextArc* [48], *Blue Dots* [5, 33–36], and *Arc Diagrams* [59] visualize these "word clusters," but are constrained by the window size of a desktop monitor. In the digital humanities, words and text strings are the typical mode of representation of mass corpora. However, new modes of lexical visualization such as *Visnomad* [57] are emerging as dynamic visualization tools for comparing one text with another. In another example, the *Visualization of the Bible* by Chris Harrison, each of the 63,779 cross references found in the Bible are depicted by a single arc whose color corresponds to the distance between the two chapters [20].

Websites such as Visual Complexity [58], and mainstream projects such as Many Eyes [42] attest to the increasing interest in information visualization. Visual Analytics is closely related to HCI and the development of gesture based computing for data retrieval [25]. Microsoft's *Project Natal* and Pranav Mistry (MIT) *Six Sense* are examples of increasing use of intuitive devices that promote kinesthetic embodied relationships with data.

In the analytics domain of the humanities, the *Cultural Analytics* as developed by UC San Diego offers us visionary trends in large screen immersive system visualization. *Cultural Analytics* researches visualization of large-scale heterogeneous data in immersive system displays. It uses computer-based techniques from quantitative analysis and interactive visualization employed in sciences to analyze massive multi-modal cultural data sets on gigapixels screens [41]. This project draws upon

Fig. 11.1 *T_Visionarium* I in EVE © UNSW iCinema Research Centre

cutting-edge cyberinfrastructure and visualization research at Calit2 (including the aforementioned new generation CAVE and Powerwall).

Previous embodied and interactive visualization systems created by researchers collaborating on projects reported in this chapter include *T_Visionarium I & II* [53]. *T_Visionarium I* was developed by iCinema Centre, UNSW in 2003. It takes place in Jeffrey Shaw's EVE, an inflatable (12 × 9 m) dome that includes a motorized pan-tilt projection system affixed to a tripod, and a head-mounted position-tracking device. EVE's database comprises a week-long recording of 80 satellite television channels across Europe. Each channel plays simultaneously across the dome; however, the user directs or reveals any particular channel at any given time. The matrix of 'feeds' is tagged with different parameters—keywords such as phrases, colour, pattern, and ambience. Using a remote control, the viewer selects options from a recombinatory search matrix. Upon parameter selection, the matrix extracts and distributes all the corresponding broadcast items related to that parameter over the entire projection surface of the dome. For example, by selecting the keyword "dialogue", all the broadcast data is reassembled according to this descriptor. The viewer head movement controls the position the projected image, and shifts from one channel's embodiment of the selected parameter to the next. In this way, the viewer experiences a revealing synchronicity between all the channels linked through the occurrence of keyword tagged images. All these options become the recombinatory tableau in which the original data is given new and emergent fields of meaning (Fig. 11.1). *T_Visionarium II* in AVIE (produced as part of the ARC Discovery, 'Interactive Narrative as a Form of Recombinatory Search in the Cinematic Transcription of Televisual Information' [53]) uses 24 h of free to air broadcast TV footage from seven Australian channels as its source material. This footage was analyzed by software for changes of camera angle, and at every change in a particular movie (whether it be a dramatic film or a sitcom), a cut was made resulting is a database of 24,000 clips of approximately 4 s each. Four researchers were employed to hand tag each 4 s clip with somewhat idiosyncratic metadata related to the images shown, including: emotion, expression, physicality, and scene structure; with metatags that include speed, gender, colour,

Fig. 11.2 *T_Visionarium* II in AVIE © UNSW iCinema Research Centre

Fig. 11.3 Datasphere, *T_Visionarium* II in AVIE © UNSW iCinema Research Centre

and so on. The result is 500 simultaneous video streams each looping 4 s, responsive to a user's search (Figs. 11.2 and 11.3).

An antecedent of the *T_Visionarium* projects can be found in Aby Warburg's Mnemosyne, a visual cultural atlas. It is a means for studying the internal dynamics of imagery at the level of its medium rather than its content, performing image analysis through montage and recombination. *T_Visionarium* can be framed by the concept of aesthetic transcription, that is, the way new meaning can be produced is based on how content moves from one expressive medium to another. The digital format allows the transcription of televisual data, decontextualising the original, and reconstituting it within a new artifact. As the archiving abilities of the digital format allow data to be changed from its original conception, new narrative relationships are generated between the multitudes of clips, and meaningful narrative events emerge because of viewer interaction in a transnarrative experience where gesture is all defining. The segmentation of the video reveals something about the predominance of close-ups, the lack of panoramic shots, and the heavy reliance on dialogue in TV footage. These aesthetic features come strikingly to the fore in this hybrid environment. The spatial

contiguity gives rise to new ways of seeing and of reconceptualising in a spatial montage [4]. In *T_Visionarium*, the material screen no longer exists. The boundary of the cinematic frame has been violated, hinting at the endless permutations that exist for the user. The user does not enter a seamless unified space, but rather is confronted with the spectacle of hundreds of individual streams.

11.3.2 Phenomenology and Visualization

At the nexus of the work for the projects *Rhizome of the Western Han* and *Pure Land* is the embodiment of the user in 360° 3D space. In both cases, the 'cave' sites used in the visualizations are shown at one-to-one scale with ultra-high resolution imagery and 3D effects providing powerful immersive experiences. There is ample discourse to situate the body at the forefront of interpretive archaeology research as a space of phenomenological encounter. Post-processual frameworks for interpretive archaeology advance a phenomenological understanding of the experience of landscape. In his book, *Body and Image: Explorations in Landscape Phenomenology*, archaeologist Christopher Tilley, for example, usefully contrasts iconographic approaches to the study of representation with those of kinaesthetic enquiry [56]. Tilley's line of reasoning provides grounding for the research into narrative agency in large-scale, immersive and sensorial, cognitively provocative environments [29, 30]. The project examines a philosophical discussion of what it means to inhabit archaeological data 'at scale' (1:1). It also re-situates the theatre of archaeology in a fully immersive display system [49]. Further discussion on these topics has been published by the researchers [30].

11.4 Project Descriptions

11.4.1 Data Sculpture Museum[1]

The aim of this research is to investigate recombinatory search, transcriptive narrative, and multimodal analytics for heterogeneous datasets through their visualization in a 360° stereoscopic space [11]. Specifically, to explore cultural data as a cultural artifact so as to expose a multiplicity of narratives that may be arranged and projected instantaneously [11] atop the data archive architecture and its metadata [12]. This project builds upon the exploration and gains made in the development of *T_Visionarium I and II*.

[1] This project is being developed as part of the Australian Research Council Linkage Grant (2011–2014) "The narrative reformulation of multiple forms of databases using a recombinatory model of cinematic interactivity" (UNSW iCinema Research Centre [1], Museum Victoria [46], ALiVE City University [3], ZKM Centre for Built Media) [62].

The datasets used contain over 100,000 multimedia rich records (including audio files, video files, high resolution monoscopic and stereoscopic images, panoramic images/movies, and text files) from Museum Victoria, and the media art history database of the ZKM that itself encompasses diverse subject areas from the arts and sciences collections. Data are collated from collection management systems, web-based and exhibition-based projects. Additional metadata and multimedia analysis is used to allow for intelligent searching across datasets. Annotation tools provide users with the ability to make their own pathways through the data terrain, a psycho-geography of the museum collections. Gesture-based interaction allows users to combine searches, using both image-based and text input methods. Search parameters include:

- Explicit (keyword search based on collections data with additional metadata tags accessible through word clouds).
- Multimedia (e.g. show me all faces like this face; show me all videos on Australia, show me everything pink!).
- Dynamic (e.g. show me the most popular search items; join my search to another co-user; record my search for others to see; add tags).
- Abstract (auto generated flow of content based on search input which results from an algorithm running through the data and returning abstract results).

This project seeks to understand the development of media aesthetics. Problems of meaningful use of information are related to the way users integrate the outcomes of their navigational process into coherent narrative forms. In contrast to the interactive screen based approaches conventionally used by museums, this study examines the exploratory strategies enacted by users in making sense of large-scale databases when experienced immersively in a manner similar to that experienced in real displays [38, 40]. In particular, evaluation studies ask: (i) How do museum users interact with an immersive 360° data browser that enables navigational and editorial choice in the re-composition of multi-layered digital information? (ii) Do the outcomes of choices that underpin editorial re-composition of data call upon aesthetic as well as conceptual processes and in what form are they expressed? [10]

Large-scale immersive systems can significantly alter the way information can be archived, accessed, and sorted. There is significant difference between museum 2D displays that bring pre-recorded static data into the presence of the user, and immersive systems that enable museum visitors to actively explore dynamic data in real-time. This experimental study into the meaningful use of data involves the development of an experimental browser capable of engaging users by enveloping them in an immersive setting that delivers information in a way that can be sorted, integrated and represented interactively. Specifications of the experimental data browser include:

- immersive 360° presentation of multi-layered, heterogeneous data
- the re-organization and authoring of data
- scalable navigation incorporating Internet functionality
- collaborative exploration of data in a shared immersive space
- intelligent, interactive system able to analyze and respond to user's transactions.

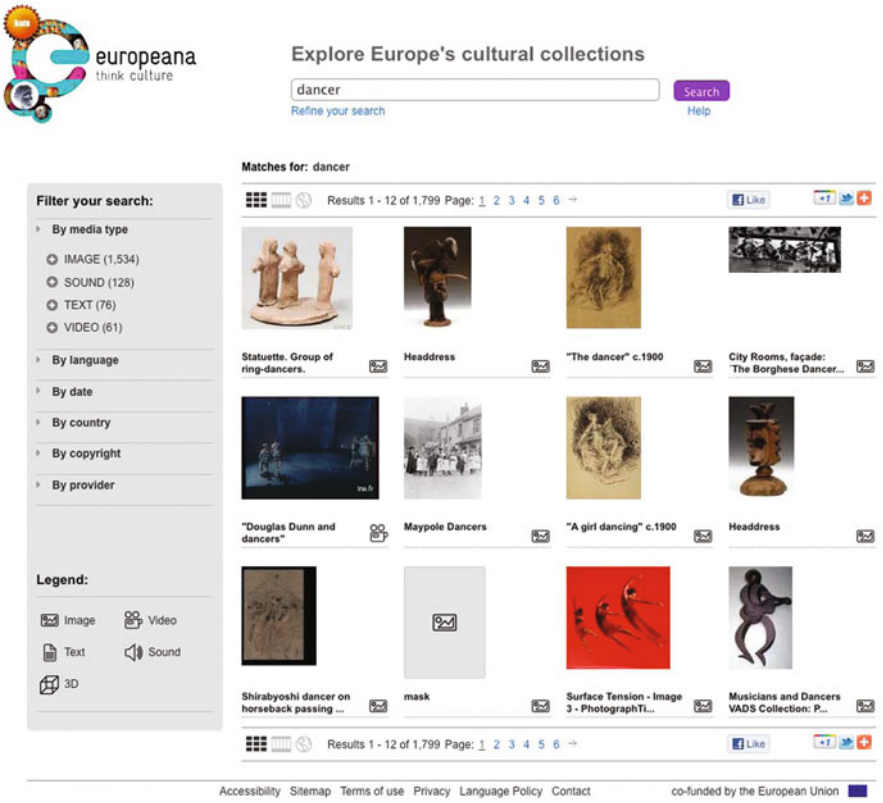

Fig. 11.4 Europeana online portal—search return. http://www.europeana.eu/portal/search.html?query=dancer. © Europeana

11.4.2 ECloud

Another prototype project under development at ALiVE is focused on providing a multi-user interactive visualization of the online cultural collection portal Europeana [15]. Around 1,500 institutions have contributed to Europeana, assembling collections of over 14 million records in multiple languages (Fig. 11.4). The recently released future directions report for Europeana [16] emphasized the need to look for innovations in delivery of content. Our prototype uses up to 10,000 objects coming from recent collections of First World War data (Fig. 11.5), distributed in 3D space across a 9 m screen employing a touch screen interface (Figs. 11.6, 11.7). We are using the limited five-field metadata that is the basis for Europeana portal for this visualization.

Fig. 11.5 Europeana online portal—WW1. http://remix.europeana.eu/. © Europeana

Fig. 11.6 Satirical maps of Europe and image clouds, *ECloud*. © ALiVE, City

Fig. 11.7 iPad interface, *ECloud*. © ALiVE, CityU

This project builds on Europeana research into new ways of searching and/or browsing. *ECloud* will take advantage of Europeana APIs and high-resolution content existing in Europeana partner repositories. The *ECloud* prototype is designed for museums and cultural organizations as a situated showcase for engaging and inspiring visitors with the vast wealth of cultural data available at Europeana. The research proposed by *ECloud* will be at the forefront of the growth of visual analytics, cultural visualization, and information aesthetics. These methodologies are essential for a world with increasingly large data streams. The project also answers the challenge presented by the increasing desirability of large screen interactive experiences that can re-invigorate public spaces. *ECloud*'s unique design offers visitors an unparalleled opportunity for creative association and discovery through enhanced cognitive enquiry. *ECloud* will extend current interaction paradigms with audio–visual materials. New schemes will be implemented to respect the sensible nature of the Europeana's First World War sets.

Europeana's work on the First World War sets out to discover untold stories, to share them across borders, and to invite responses from around Europe. This project has collected over 24,000 records already and more are planned as the project moves throughout Europe. *ECloud* will incorporate this data giving audiences a situated experience of this crowdsourced collection providing a powerful graphic world based on individual recollections and family archives on this highly emotional subject. Based on comparative and analytic approaches to data mining, this work transforms the archive into palpable universe of emotion, with significant cognitive impact.

11.4.3 Blue Dots 360

This project integrates the Chinese Buddhist Canon, Koryo version Tripitaka Koreana into the AVIE system (a project between ALiVE, CityU Hong Kong, and UC Berkeley). This version of the Buddhist Cannon is inscribed as UNESCO World

Fig. 11.8 Tripitaka Koreana. Image © Caroline Knox (Wikipedia commons, http://en.wikipedia.org/wiki/File:Korea-Haeinsa-Tripitaka_Koreana-04.jpg)

Heritage enshrined in Haeinsa, Korea. The 166,000 pages of rubbings from the wooden printing blocks constitute the oldest complete set of the corpus in print format (Fig. 11.8). Divided into 1,514 individual texts, the version has a complexity that is challenging since the texts represent translations from Indic languages into Chinese over a 1,000-year period (second–eleventh century). This is the world's largest single corpus containing over 50 million glyphs and it was digitized and encoded by Prof Lew Lancaster and his team in a project that started in the 1970s [33–36].

Amount of content

- 1,504 texts
- 160,465 pages
- 52,000,000 glyphs
- 1 text includes 107 pages (34,674 glyphs)
- 1 page includes 324 glyphs arranged in 23 rows and 14 columns.

Contextual information

- 1,504 colophons with titles, translators, dates, places, and other information
- 202 people names (translators, authors, compilers)
- 98 monastery names.

The *Blue Dots* [5] project undertaken at Berkeley as part of the Electronic Cultural Atlas Initiative (ECAI; [14]) which abstracted each glyph from the Canon into a blue dot, and gave metadata to each of these *Blue Dots* allowing vast searches to take place in minutes which would have taken scholars years. In the search function, each blue dot also references an original plate photograph for verification. The shape of these wooden plates gives the blue dot array its form (Fig. 11.9).

As a searchable database, it exists in a prototype form on the Internet. Results are displayed in a dimensional array where users can view and navigate within the image. The image uses both the abstracted form of a "dot" as well as color to inform the

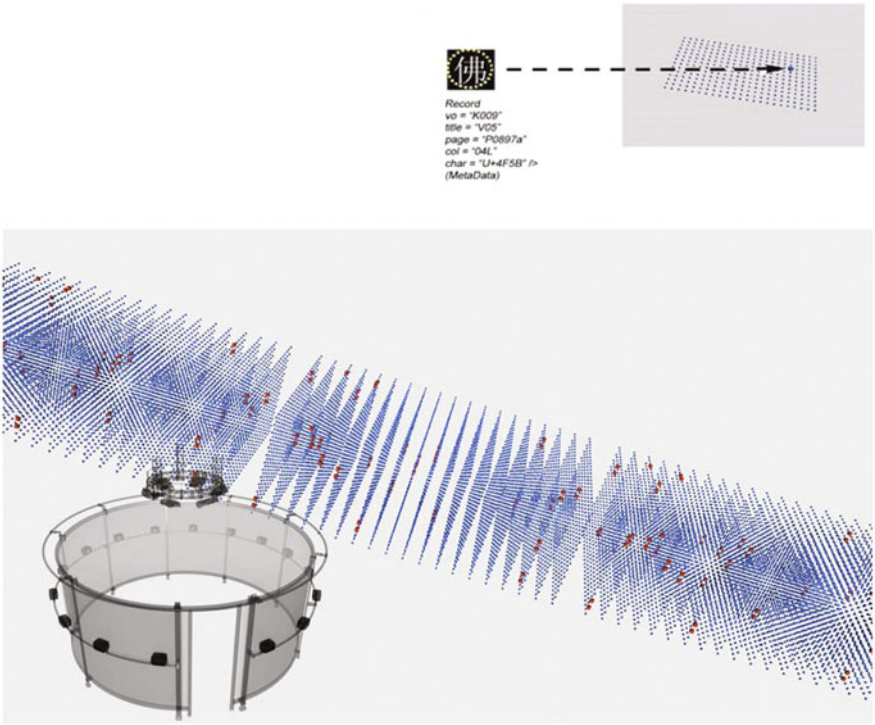

Fig. 11.9 *Blue Dots*: abstraction of characters to dots and pattern arrays © ECAI, Berkeley

user about the information being retrieved. Each blue dot represents one glyph of the dataset. Alternate colors indicate position of search results. The use of colour, form, and dimension to quickly communicate understanding of the information is essential for large data sets where thousands of occurrences of a target word/phrase may be seen. Analysis across this vast text retrieves visual representations of word strings, clustering of terms, automatic analysis of ring construction, viewing results by time, creator, and place. The *Blue Dots* method of visualization is a breakthrough for corpora visualization and lies at the basis of the visualization strategies of abstraction undertaken in this project. The application of an omnispatial distribution of these texts solves problems of data occlusion and enhances network analysis techniques to reveal patterns, hierarchies and interconnectedness (Figs. 11.10 and 11.11). Using a hybrid approach to data representation, audification strategies will be incorporated to augment interaction coherence and interpretation. The data browser is designed to function in two modes: the Corpus Analytics mode for text only and the Cultural Atlas mode that incorporates original text, contextual images, and geospatial data. Search results can be saved and annotated.

The current search functionality ranges from visualizing word distribution and frequency to other structural patterns such as the chiastic structure and ring compositions. In the *Blue Dots AVIE* version, the text is also visualized as a matrix of

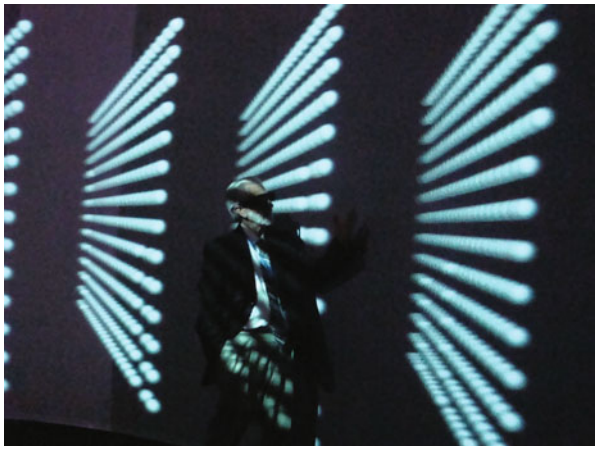

Fig. 11.10 Prof Lew Lancaster interrogates the Prototype of *Blue Dots 360* © ALiVE, CityU. Image: Howie Lan

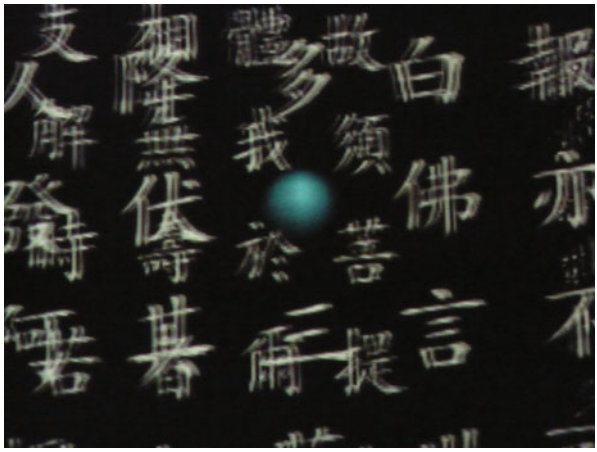

Fig. 11.11 Close up of *blue dots* and corresponding texts, Prototype of *Blue Dots 360* © ALiVE, CityU. Image: Howie Lan

simplified graphic elements representing each of the words. This will enable users to identify new linguistic patterns and relationships within the matrix, as well as access the words themselves and related contextual materials. The search queries will be applied across classical Chinese and eventually English, accessed collaboratively by researchers, extracted and saved for later re-analysis.

The data provides an excellent resource for the study of dissemination of documents over geographic and temporal spheres. It includes additional metadata such as present day images of the monasteries where the translation took place, which will be included in the data array. The project will design new omnidirectional metaphors for interrogation and the graphical representation of complex relationships between these textual datasets to solve the significant challenges of visualizing both abstract forms and close-up readings of this rich data (Figs. 11.12 and 11.13). In this way, we hope to set benchmarks in visual analytics, scholarly analysis in the digital humanities, and the interpretation of classical texts.

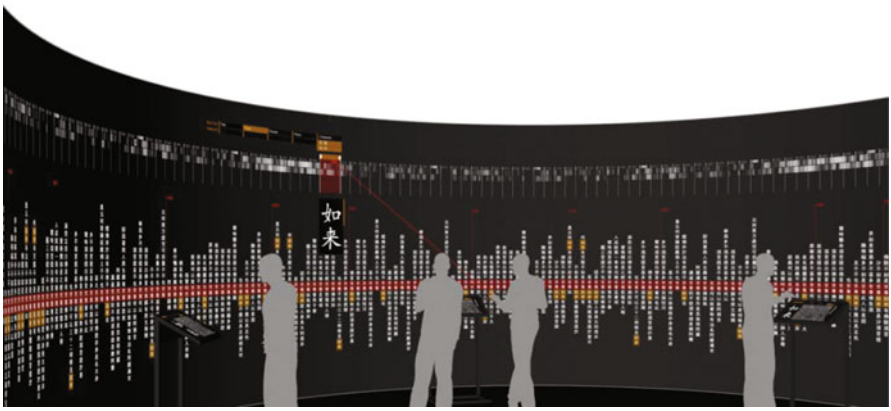

Fig. 11.12 Visualization of *Blue Dots 360*. Image: Tobias Gremmler © ALiVE, CityU

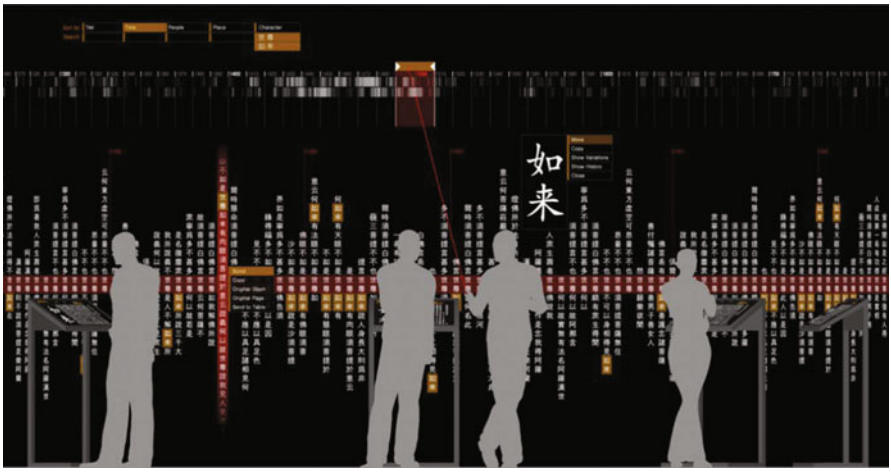

Fig. 11.13 Visualization of *Blue Dots 360*. Image: Tobias Gremmler © ALiVE, CityU

11.4.4 Rhizome of the Western Han

This project investigates the integration of high-resolution archaeological laser scan and GIS data inside AVIE. This project represents a process of archaeological re-contextualization, bringing together in a spatial context remote sensing data from two tombs (M27 and The Bamboo Garden) with laser scans of funerary objects. This prototype builds an interactive narrative based on spatial dynamics, and cultural aesthetics and philosophies embedded in the archaeological remains. The study of the Han Dynasties' (206 BC–220 AD) imperial tombs has always been an important field of Chinese archaeology. However, only a few tombs of the West Han Dynasty have been scientifically surveyed and reconstructed. Further, the project investigates

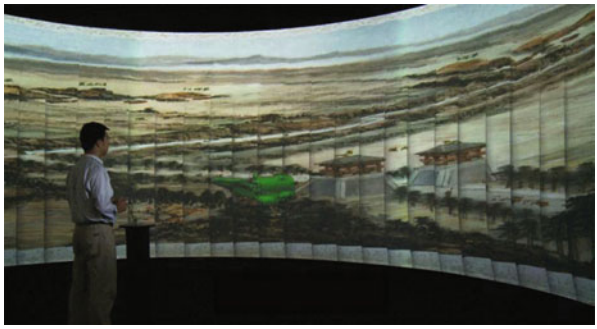

Fig. 11.14 *Rhizome of the Western Han*: inhabiting the tombs at 1:1 scale © ALiVE, CityU

Fig. 11.15 *Rhizome of the Western Han*: inhabiting the tombs at 1:1 scale © ALiVE, CityU

a reformulation of narrative based on the application of cyber-mapping principles in archaeology [17, 28, 32].

The application engine has been developed in order to be completely dynamic and not dependent on the application data. Every environment, information, models and behaviors are specified and loaded from a configuration file. When the application starts, the user is surrounded by an introductory 3D level. This scenario allows the user to select between various real 3D archaeological reconstruction scenarios through intuitive iconic representations. This Scene Browser is dynamically created according to the total amount of models available for the application (in the Western Han case of study it is possible to select between two different tomb reconstructions and a 3D objects browser). The engine is able to generate two types of scenarios with different behaviors and user experiences (Figs. 11.14, 11.15 and 11.16).

The second type of environment (the Object Viewer) displays multiple virtual reconstructions of objects around the user in a circular manner. The user can browse, magnify, and manipulate every object independently. The object browser experience is also improved thanks to the visualization of a facultative cloud of points in which the objects float.

This prototype has led to the construction of an interactive installation (*Pure Land*) using laser scan data from the UNESCO World Heritage site of the Dunhuang Caves (Magao Grottoes), Gobi Desert, China.

Fig. 11.16 *Rhizome of the Western Han*: object browser © ALiVE, CityU

11.4.5 Pure Land

Pure Land: Inside the Mogao Grottoes at Dunhuang immerses visitors in the quintessential heritage of hundreds of Buddhist grotto temples, an art treasury abounding with murals, statues, and architectural monuments. Filled with paradisiacal frescos and hand-molded clay sculptures of savior-gods and saints, they are, in size and historical breadth, like nothing else in the Chinese Buddhist world [24]. This UNESCO World Heritage site, also known as the *Caves of the Thousand Buddhas* or the *Peerless Caves,* is located at Dunhuang, a small town in northwestern China, an oasis amid the Gobi desert. It was a gateway to and from China on the ancient Silk Road, which carried trade between China, western Asia and India from the 2nd century BC until the 14th century AD.

Pure Land is an interactive 3D exhibition that takes place in the world's first 360° stereoscopic panoramic enclosure AVIE. *Pure Land* is significant because it provides a new paradigm of interpretation for the rich and intricate narratives rendered on the cave walls, in high fidelity, at 1:1 scale and in 3D. The Magao Grottoes have been subject to extensive digital imaging for conservation, preservation, and education undertaken by the custodians of the site, the Dunhuang Academy [13]. The photographic projects at Dunhuang, unparalleled in scale when compared to any other World Heritage site, is a race to 'capture' and preserve the caves before any more degradation can occur. *Pure Land* makes use of this high-resolution photography and laser scanning data to tell stories about the extraordinary wealth of paintings found in the caves at Dunhuang.

The site includes 492 caves that still contain rich murals and sculptures (there are over 700 in total). With increasing number of caves at Dunhuang closed to the public (approximately 10–29 are viewable out of 100), it is considered likely that, at some point in the future, all these caves will be closed to ensure their extended preservation. As such, the visitors may only use weak torchlight to examine the cave walls.

> And Mogaoku is in trouble. Thrown open to visitors in recent decades, the site has been swamped by tourists in the past few years. The caves now suffer from high levels of carbon dioxide and humidity, which are severely undermining conservation efforts. The short-term solution has been to limit the number of caves that can be visited and to admit people only on timed tours, but the deterioration continues. . . Plans are under way to recast the entire

Fig. 11.17 *Pure Land* visualization. Image: Tobias Gremmler © ALiVE, CityU/Dunhuang Academy

> Dunhuang experience in a way that will both intensify and distance it. Digital technology will give visitors a kind of total immersion encounter with the caves impossible before now. . . [9]

Closing important and unique world heritage caves to ensure preservation is an increasing worldwide trend. France's Lascaux closed in 1963. Lascaux II, a replica of two of the cave halls—the Great Hall of the Bulls and the Painted Gallery—was opened in 1983, 200 m. from the original. Reproductions of other Lascaux artwork can be seen at the Centre of Prehistoric Art at Le Thot, France. Spain's famous Altamira Cave has been frequently closed and is currently closed due to fungus infestations). *Pure Land* represents an innovation in providing not only a truly representative virtual facsimile, an extensive range of tools for its exploration, analysis and understanding, but also an embodied experience of this wondrous place.

Inside *Pure Land*, the visitors enter a panoramic laser scan image of the escarpment at Dunhuang to encounter a constellation of iconography from a myriad of caves. Visitors can enter inside Cave 220. Using both a torch and magnifying glass interface, the intricate iconography can be brought to life in great detail. Each wall of the Cave is resplendent with narrative and *Pure Land* employs a range of 2D and 3D animations and 3D videos to bring the paintings to life. For example, the *Bhaisajyaguru Sutra* recorded the rituals of subsisting the seven Medicine Buddhas. The painting reveals how human pray to keep away from sufferings and illness. The *Western Pure Land Sutra* or the sutra of *Infinite Life* tells about the Amitabha Buddha who sits among the solemn and beautiful scenes depicted. Here, believers are no longer afraid of death and long for rebirth in the 'other' world. Rich with interactive features, *Pure Land* transports visitors to these other realms.

Pure Land is a forerunner in the use of advanced technologies for cultural heritage interpretation of digital preservation, and new museography (Figs. 11.17, 11.18, 11.19 and 11.20). A full technical description of this work, developed in an extended Virtools framework is forthcoming.

Fig. 11.18 Close-up detail of North Wall Cave 220 with magnifying glasses effect, *Pure Land.* Image: Sarah Kenderdine © ALiVE, CityU/Dunhuang Academy

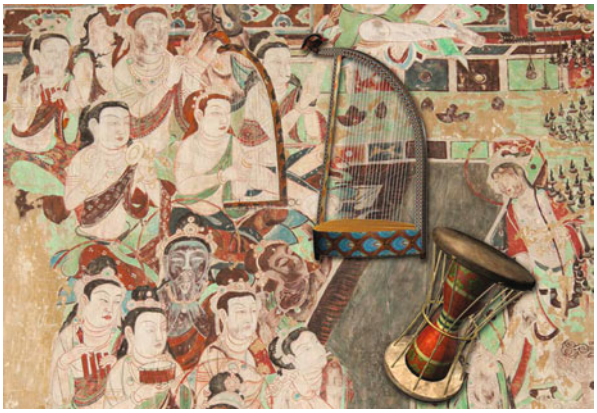

Fig. 11.19 Interactive 3D instrument inside CAVE 220, *Pure Land*. Image: Jonathan Chan © ALiVE, CityU/Dunhuang Academy

Fig. 11.20 Stereographic video capture of Beijing Academy Dancers, *Pure Land.* Image: Digital Magic © ALiVE, CityU/Dunhuang Academy

11.5 Conclusion

The five projects described begin take on core challenges of visual analytics, multimedia analysis, text analysis, and visualization inside AVIE to provide powerful

modalities for an omnidirectional exploration of museum collections, archaeological laser scan data, and multiple textual datasets. This research responds to the need for embodied interaction and knowledge-based interfaces that enhance collaboration, cognition, perception, and narrative coherence. For instance, through AVIE, museum users and scholars are investigating the quality of narrative coherence of abstract and multimedia data through interactive navigation and re-organization of information in 360° 3D space. There will be ongoing reporting related to the *Data Sculpture Museum*, which has recently commenced as part of a three-year project, and the *Blue Dots 360*. The upcoming work on the interactive installation *Inside Dunhuang* will also be the subject of separate reports.

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