

# Cultural Data Sculpting: Omnispatial Visualization for Cultural Datasets

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**Abstract**—This paper presents four research projects currently underway to develop new omnispatial visualization strategies for the collaborative interrogation of large-scale heterogeneous cultural datasets using the worlds’ 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, 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 Museum Victoria (Melbourne), iCinema Centre, UNSW (Sydney), ZKM Centre for Art and Media (Karlsruhe), UC Berkeley (USA), UC Merced (USA) and and Europeana (in association with Israel Museum of Jerusalem). The applications are intended for museum visitors and for humanities researchers. They are: (1) Data Sculpture Museum; (2) Inside Europeana; (2) Rhizome of the Western Han; (4) Blue Dots AVIE (Tripitaka Koreana).

**Keywords**—3D; immersive; information visualization; interactive narrative; museum collections; archaeology; corpora

## I. INTRODUCTION

Research into new modalities of visualizing data is essential for a world producing and consuming digital data at unprecedented rates [24, 40]. Existing techniques for interaction design in visual analytics rely upon visual metaphors developed more than a decade ago [25] such as dynamic graphs, charts, maps, and plots. Currently, interactive, immersive and collaborative techniques to explore large-scale datasets lack adequate experimental development essential to the construction of knowledge in analytic discourse [46]. Recent visualization research remains largely constrained to 2D small-screen based analysis and advances interactive techniques of “clicking”, “dragging” and “rotating” [24, 48]. Furthermore, the number of pixels available to the user remains a critical

limiting factor in human cognition of data visualizations [23]. The increasing trend towards 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 [20] and, next generation immersive virtual reality systems, StarCAVE at UC San Diego [9] and Allosphere at UC Santa Barbara [2].

In general, however 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 [26]. The four projects described in this paper take on these core challenges of visual analytics inside the Advanced Visualization and Interaction Environment (AVIE) [1] [41] (also see Section 2.1) to provide powerful modalities for an omnispatial/omnidirectional (3D, 360-degree) exploration of heterogeneous datasets responding to the need for embodied interaction; knowledge-based interfaces, collaboration, cognition and perception [46]. The projects are developed by the Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), CityU, Hong Kong [3]. A framework for ‘enhanced human higher cognition’ [16] 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, autopoiesis [39] and promotes non-vertical and lateral thinking [43]. 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 four projects discussed also leverage the potential inherent in a combination of ‘unlimited screen real-estate’, ultra-high stereoscopic resolution and 360-degree immersion to resolve problems of data occlusion and distribution of large-scale data analysis in networked sequences revealing patterns, hierarchies and interconnectedness. The omnidirectional interface

prioritizes ‘users in the loop’ in an egocentric model [23]. The 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 and others [7]. Sonification reinforces spatial and temporal relationships between data (e.g. the objects location in 360-degrees/infinite 3D space and its interactive behavior (for example, see [57])). The multi-channel spatial array of 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.

## II. EXPERIMENTAL PROJECTS

The four experimental projects included in this paper 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 four 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 a museum contexts.
- *Inside Europeana*: 5000 objects from the Israel Museum of Jerusalem, collaborative searching, live from Internet.
- *Rhizome of the Western Han*: laser-scan archaeological datasets from two tombs and archaeological collections of the Western Han, Xian, China culminating in a metabrowser and interpretive cybermap, for general public use in a museum contexts.
- *Blue Dots AVIE*: 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 13th 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.

## A. Advanced Visualization and Interaction Environment

Applied Visualization Interaction Environment (AVIE) is the UNSW iCinema Research Centre’s landmark 360-degree stereoscopic interactive visualization environment spaces. The updated active stereo projection system together with camera tracking s installed at ALiVE. The base configuration is a cylindrical projection screen 4 meters high and 10 meters 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. [41]

## III. TECHNIQUES FOR CULTURAL DATA ANALYSIS AND VISUALIZATION

The intersection of key disciplines related to the projects in this paper includes multimedia analysis, visual analytics, and text visualization. An excellent review of the state of the art for multimedia analysis and visual analytics appeared in *IEEE Computer Graphics and Applications* [6]. The research projects also responds to core challenges and potentials identified in Visual Analytics [51, 25] and to key emerging technologies for the coming years such as Visual Data Analysis and Gesture Based Computing [22]. 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 [23]. Computational linguistics is providing many of the analytics tools required for the mining of digital texts (e.g. [48, 50]) The first international workshop for intelligent interfaces to text visualization only recently took place in Hong Kong, 2010 [35]. Most previous work in text visualization 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. It can also show changes in frequencies of words through time [19] and in different organizations [8] and emotions in different geographical locations [17]. The significance of a word also lies in the locations at which it occurs. Tools such as *TextArc* [44], *Blue Dots* [5, 29, 30, 31, 32] and *Arc Diagrams* [56] visualize these “word clusters” but are constrained by the small window size of a desktop monitor. In the digital humanities, words and text strings is the typical mode of representation of mass corpora. However, new modes of lexical visualization such as *Visnomad* [50] are emerging as dynamic visualization tools for comparing one text with another. I another example the *Visualization of the Bible* by Chris Harrison where 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 [17].

Visual Analytics is closely related to HCI and the development of gesture based computing for data retrieval [22]. 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, *Cultural Analytics* as developed by UC San Diego, offers us visoinary 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 [37]. This project draws upon cutting-edge cyberinfrastructure and visualization research at Calit2 (including the aforementioned new generation CAVE and Powerwall).

#### IV. RELATED WORKS BY RESEARCHERS

Previous embodied and interactive systems visualization by the researchers collaborating on projects in this paper includes *T\_Visionarium I & II* [49]. *T\_Visionarium I* was developed by iCinema Centre, UNSW in 2003. It takes place in the Jeffrey Shaw's EVE dome, an inflatable (12 meters by 9 meters). Upon entering the dome, the viewer places a position-tracking device onto their head. The projection system is fixed on a motorized pan tilt apparatus mounted on a tripod. The database used here was recorded during a week-long period from 80 satellite television channels across Europe. Each channel plays simultaneously across the dome however, the user directs or reveals any particular channel at any one time. The matrix of 'feeds' is tagged with different parameters - keywords such as phrases, color, pattern, and ambience. Using a remote control, the viewer selects options from a recombinatory search matrix. On selection of a parameter, the matrix then extracts and distributes all the corresponding broadcast items of 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, by moving their head in different directions and thus the position of the projected image, 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 by 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 (Figure 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') [49] uses 24 hours of free to air broadcast TV footage from 7 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 in a database of 24,000 clips of approx. 4 seconds each. Four researchers were employed to hand tag each 4 second clip with somewhat idiosyncratic metadata related to the images shown including emotion; expression; physicality; scene structure; with metatags including speed; gender; colour and so on. The result is 500 simultaneous video streams looping each 4 seconds, and responsive to a users search (Figures 2 & 3).



Figure 1. *T\_Visionarium I* © UNSW iCinema Research Centre.

An antecedent of the *T\_Visionarium* projects can be found in Aby Warburg's, *Mnemosyne*, a visual cultural atlas, a means of 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 allows the transcription of televisual data, decontextualising the original, and reconstituting it within a new artifact. As the archiving abilities of the digital 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, 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. Nor does the user enter a seamless unified space but is confronted with the spectacle of hundreds of individual streams. Pannini's picture galleries also hint at this infinitely large and diverse collection, marvels to be continued beyond the limits of the picture itself.



Figure 2. *T\_Visionarium II* in AVIE © UNSW iCinema Research Centre.

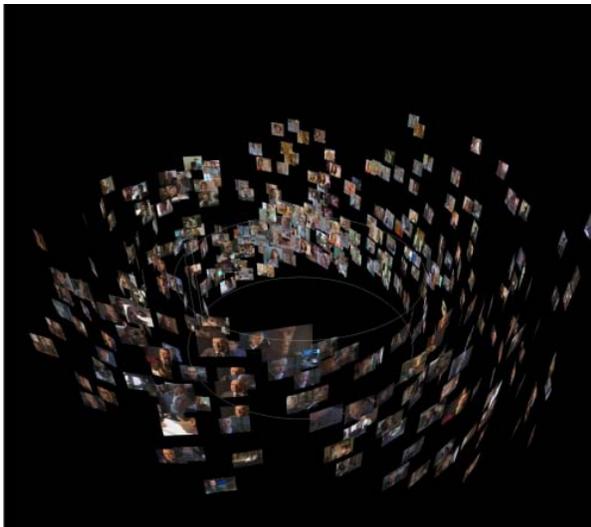


Figure 3. Datasphere, *T\_Visionarium II* © UNSW iCinema Research Centre.

## V. CURRENT WORK

### A. Data Sculpture Museum

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 [60], Museum Victoria [53], ALiVE City University [3], ZKM Centre for Built Media) [59]. 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 [10]. Specifically, the exploration of re-combinatory search of cultural data (as a cultural artefact) as an interrogative, manipulable and transformative narrative, responsive to and exposing of multiple narrations that can be arranged and projected momentarily [10] over that which is purposefully embedded

and recorded in the architecture of data archive and metadata and witnessed [11]. This project builds upon the exploration and gains made in the development of *T\_Visionarium I and II*.

The datasets used include 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 [60] that include diverse subject areas from the arts and sciences collections. The data is collated from collection management systems and from web-based and exhibition-based projects. Additional metadata and multimedia analysis will be used to allow for intelligent searching across datasets. Annotation tools will provide users with the ability to make their own pathways through the data terrain, a psycho geography of the museum collections. Gesture-based interaction will allow users to combine searches, using both image-based and text input methods. Search parameters include:

- Explicit (keyword search based on collections data and extra metadata tags added using the project 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 generate a flow of content based on my search input which results from an algorithm running through the data and returning abstract results)

This project seeks understanding in the developments 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 [33]. In particular, evaluation studies will ask: i) How do museum users interact with an immersive 360-degree 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]

Recent advent of large-scale immersive systems can significantly altered 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 the user by enveloping them in an immersive setting that delivers information in a way that can be sorted, integrated and represented interactively. Specifications of the proposed experimental data browser include:

- immersive 360-degree data browser presenting multi-layered and heterogeneous data;
- re-compositional system enabling the re-organization and authoring of data;
- scalable navigational systems incorporating Internet functions;
- collaborative exploration of data in a shared immersive space by multiple users;
- intelligent interactive system able to analyze and respond to user's transactions.

### B. Inside Europeana

Another prototype project under development at ALiVE which forms the basis for upcoming projects is focused on providing a multi-user interactive visualization of the online cultural collection portal Europeana [13]. Around 1500 institutions have contributed to Europeana and their assembled collections of over 14 million records in multiple languages (Figure 4). The recently released future directions report for Europeana [14] emphasized the need to look for innovations in delivery of content. Our prototype uses 5000 objects coming from the collection of Israel Museum of Jerusalem, inside AVIE (Figures 5, 6). We are using the limited five-field metadata that is the basis for Europeana portal for this visualization, and the data itself will come live from the internet repository using the API.

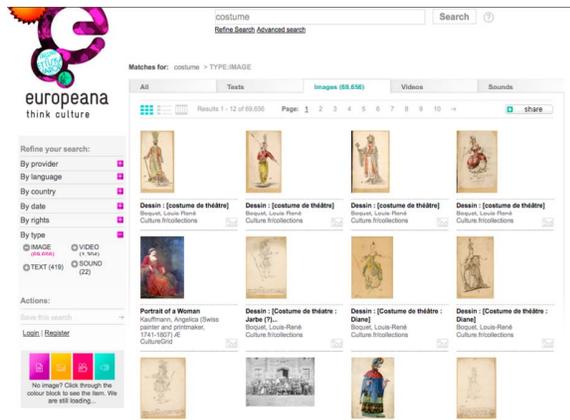


Figure 4. Europeana online portal - current search return © Europeana.

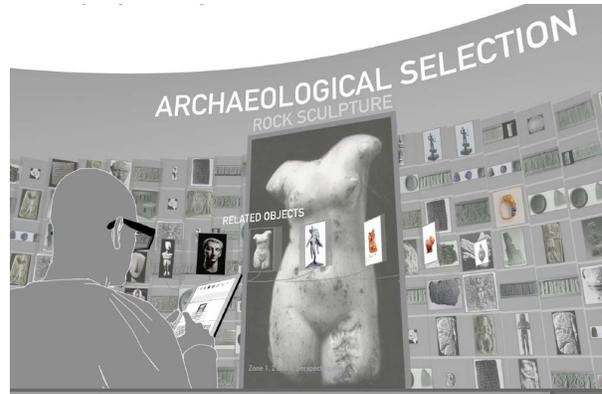


Figure 5. 3D data distribution of IMJ Europeana dataset in AVIE. Image: Tobias Gremmler © ALiVE, CityU

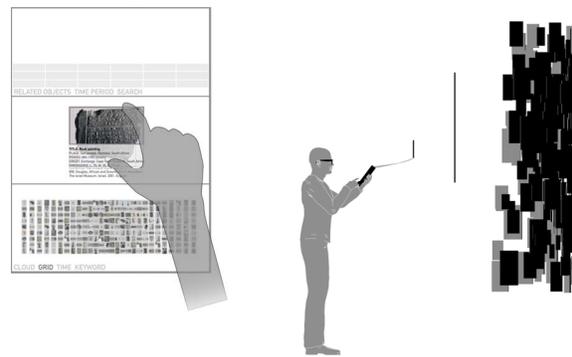


Figure 6. iPad interface and 3D data distribution of IMJ Europeana dataset in AVIE. Image: Tobias Gremmler © ALiVE, CityU

### C. 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 recontextualization, bringing together remote sensing data from the two tombs (M27 & The Bamboo Garden) with laser scans of funerary objects, in a spatial context. This prototype builds an interactive narrative based on spatial dynamics, and cultural aesthetics and philosophies embedded in the archaeological remains. The study of Han Dynasties (206 BC 220 A.D.) 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 a reformulation of narrative based on the application of cyber mapping principles in archaeology [15, 28].

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 an 3D objects browser). The engine is able to generate two type of scenario with different behaviors and user experiences (Figure 7).

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 point where the objects are floating in.



Figure 7. *Rhizome of the Western Han*: inhabiting the tombs at 1:1 scale © ALiVE, CityU.

At the nexus of this work is the embodiment of the user in 360-degree 3D space. 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 [52]. Tilley's line of reasoning provides grounding for the research into narrative agency in large-scale, immersive and sensorial, cognitively provocative environments [26]. This 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, as 'the (re)articulation of fragments of the past as real-time event' [45].

This prototype has led to a new project to build an interactive installation (*Inside Dunhuang*) using laser scan data from the UNESCO World Heritage site of the Dunhuang Caves (Mogao Grottoes), Gobi Desert, China.

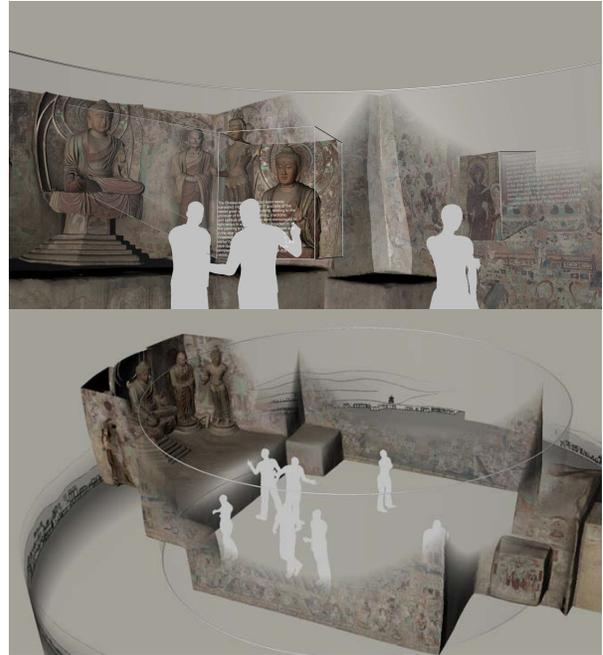


Figure 8. Visualizations of CAVE 220 inside AVIE. Image: Tobias Gremmler © ALiVE, CityU/Dunhuang Academy

This work is in collaboration with the Dunhuang Academy and the Friends of Dunhuang. Initially data from CAVE 220 will be incorporated into AVIE, together with multiple interactive features (Figure 8). The work uses ultra high resolution imaging data to tell stories about the extraordinary wealth of paintings found in the caves at Dunhuang, a nexus of cultural interchange via the Silk Road between China, India, Persian, Greco-Roman and Central Asia. The site is world renown for its art treasures and has been subject to extensive digital imaging for conservation and preservation.

#### D. *Blue Dots AVIE*

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 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 (Figure 9). 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 1000-year period (2nd-11th centuries). 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 70s [29, 30, 31, 32].

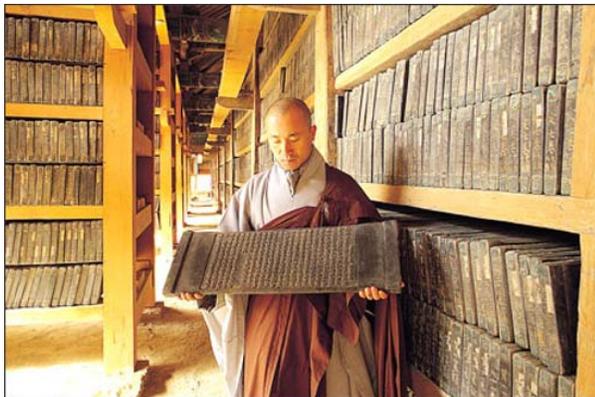
1) *Amount of content*

- 1.504 texts
- 160.465 pages
- 52.000.000 glyphs
- 1 text includes 107 pages (34674 glyphs)
- 1 page includes 324 glyphs arranged in 23 rows and 14 columns

2) *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) 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 (Figure 10).



A Buddhist monk shows one of the wooden printing blocks of the Tripitaka Koreana, housed in Haein Temple, South Gyeongsang Province. The blocks are regarded as one of the nation's greatest treasures and a valuable religious heritage of the world. / Korea Times File

Figure 9. Tripitaka Koreana © Korean Times  
([http://www.koreatimes.co.kr/www/news/art/2010/03/293\\_61805.html](http://www.koreatimes.co.kr/www/news/art/2010/03/293_61805.html))

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 user of the information being retrieved. Each blue dot represents one glyph of the dataset. Alternate colors indicate position of search results. The use of color, form, and dimension for a fast 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 this text solves problems of data occlusion, and enhances network analysis techniques to reveal patterns, hierarchies and interconnectedness (Figures 11 & 12). 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 texts, 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 chiasmic structure and ring compositions. In the *Blue Dots AVIE* version, the text is also visualized as a matrix of 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 is 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 (Figures 13 & 14). In this way, it we hope to set benchmarks in visual analytics, scholarly analysis in the digital humanities and, the interpretation of classical texts.

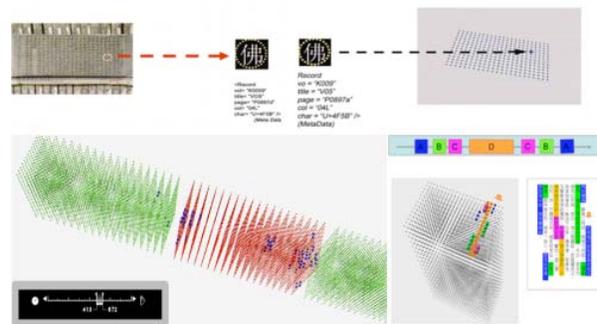


Figure 10. *Blue Dots*: abstraction of characters to dots and pattern arrays  
© ECAI, Berkeley.



Figure 11. Prof Lew Lancaster interrogates the Prototype of *Blue Dots AVIE* © ALiVE, CityU.  
Image: Howie Lan

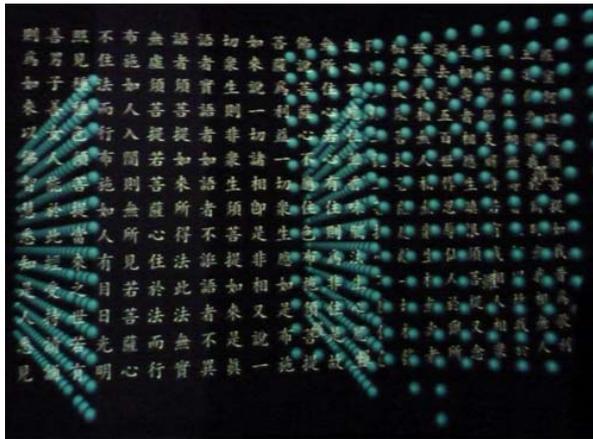


Figure 12. Close up of blue dots & corresponding texts, Prototype of *Blue Dots AVIE* © ALiVE, CityU. Image: Howie Lan

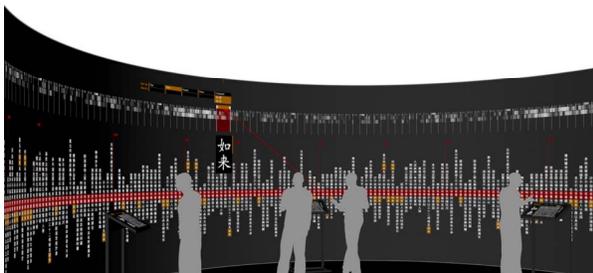


Figure 13. Visualization of *BLUE DOTS AVIE*. Image: Tobias Gremmler © ALiVE, CityU.



Figure 14. Visualization of *BLUE DOTS AVIE*. Image: Tobias Gremmler © ALiVE, CityU.

## VI. CONCLUSION

The four projects described begin to 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. The research is responding to the need for embodied interaction and knowledge-based interfaces that enhance collaboration, cognition and 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-degree 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 AVIE*. The upcoming work on the interactive installation *Inside Dunhuang* will also be the subject of separate reports.

## ACKNOWLEDGEMENTS

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Researchers: Assoc Prof Dr Sarah Kenderdine, Prof Maurizio Forte, Carlo Camporesi, Prof Jeffrey Shaw. *Blue Dots: Tripitaka Koreana*. Partners: ALiVE, City University of Hong Kong, UC Berkeley, Researchers: Assoc Prof Dr Sarah Kenderdine, Prof Lew Lancaster, Howie Lan, Prof Jeffrey Shaw, Tobias Gremmler

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