Emergent Relationality System

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Abstract

The Emergent Relationality System is a work in progress that enfolds multiple research agendas. The system seeks to define a new wholistic approach to CyberArcheology including new forms of multi-modal sensor hardware to work in conjunction with current sensor systems; a new software/search paradigm; and a novel generative virtual environment; to empower the user to bring media materials into "intelligent" proximity/juxtaposition. This system seeks to include the visualization of multiple kinds of sensor data relevant to CyberArcheology as it is brought into dynamic relation with media elements that might not normally exist in the same associational virtual space. Here polysensing systems (parallel multimodal sensing over time) enable the creation of a form of media object that can be given additional meta-data, and can be explored via state of the art search algorithms, new meta mark-up methodologies, and virtual visualization. The system is modular and non-hierarchical and hence a potentially combinatoric modular format is explored in the text.

Key Words – CyberArcheology, sensing systems, database system, intelligent network, associational space, VR, learning system

When one attends contemporary conferences related to CyberArcheology, one notices on the one had the incredible exploration and proliferation of new sensing technologies and alternately one gets the feeling that a form of wholism related to the digital-archeological project is missing. Of course the concept of artifacts, locations and cultural processes, and how they can be

addressed to form a proposed "picture" of a historical time/space is central to this research. The capture of multiple forms of digital sensing processes enables new access to the relational, in the spirit of ongoing understanding, in particular via the intelligent mining of relational databases through linguistic and pattern related means. Here we seek to form a deep accretive notion of context via computational means. Let me here give a simple example of differing media that might be brought into relation to help extend our understanding of context. One person might be focused on the photography of a particular site as drawn from historical archives; another might be interested in contemporary oral histories that have been passed down; a third might be looking deeply into the archives of past research; and a forth foci might be using contemporary digital tools to scan and map the site— the sensing technologies that are central to this text. New forms of multi-modal visualizations become an essential new form of media-element. Of course the project is never finished but is always unfolding, adding new layers of meaning as an ongoing process over time. Often different areas of research are kept separate. My contention is that if they can be brought into relation, where sensing data is dynamically juxtaposed with other forms of media objects, via new computational methodologies, this relationality might bring insight to a more holistic historical understanding.

This suggests the necessitity of authoring an extensible intelligent network of multi-perspective knowledge production technologies. These could be explored through the enfolding of multiple forms of mapping, multi-modal data collection and subsequent visualization (polysensing), storage, annotation, text analysis, pattern analysis, AI, and insight production systems.

My goal is to articulate a multi-modal sensing environment that is linked to a networked virtual space, related database and 'intelligent' media connectivity systems. If we draw from human sensing as a model, we can employ multiple senses to provide for us a multi-perspective understanding of an environment over time. How can we re-apply this methodology to enhance our understanding of new forms of relational technological artifacts? One foci is to collect a stream of bio-mimetic multi-modal pattern flows of sensed data as derived from a series of different linked machinic sensing systems

including multiple sensors on a chip [employing as many chips as needed for different sites]. This kind of complex chip or unit including multiple sensors could function in conjunction with other sensing/scanning technologies that are being employed at a given site via new forms of database mining and subsequent relational visualization. Here, the time-based layering of data from differing sensors begins to present coherent data-objects in a similar fashion to that of the how the human builds up knowledge of context over time. Here a site-based virtual timeline becomes one organizing methodology. One will also be able link and/or intermingle "associated" "informational" data of relevance via differing linguistic data-mining methodologies – e.g. coherent textual mark-ups giving an extended voice to differing digital objects in the database, key-words, meta-tags, etc— sensing data in particular will also be visualized (and/or sonified) in new ways that make it easy to juxtapose with other media elements. The potential is to link an Internet of Things and new forms of sensing, with particular spatial environments and distributed researchers from differing, yet related fields creating a more extensive operative holistic CyberArcheology.

Additionally in the future one seeks to extend these multi-modal sensing environments with new forms of light sensors enabling intelligent transduction of multi-modal sensor data. The potentials of new forms of bio-abstracted robots that might have mobile Polysensing environments linked to particular "learning" systems are also of long-term value. One also seeks to create a flexible "Grammar of Attention" for the sensors that is easily coded by a remote observer via an "Emergent Intention Matrix", an object–based coding system. Imagine that one could scroll though a list of functionalities, and easily choose (through a menu system) to have a particular sensor "pay attention" to the site in a specific way, e.g. track the light as it changes over a period of time. It could then communicate with the smart sensor system and undertake this particular functionality. Such a system can be applied to many different kinds of environment— scientific, artistic, and humanities related. One can easily see the specific relevance of such a project to CyberArcheology. Additonal new technologies might be brought into the network including Seaman's concept of the R-map (Room / Region / Relation Mapping) which explores the mapping of a space via multiple video zooms, fanning out in 180 or 360 degrees, that

can later be navigated (moving in and out of the zoom) providing detailed images of surfaces as well as wider angle images collected in the zoomed-out mode. This system creates a video virtual space. Hypothetically this space could also be annotated at specific parts of the zoom, and searched in relation to semantic, syntactic and statistical textual information as well as pattern-oriented information.

The Relational World Generator is also in the initial production stages. This system would link a database of sense-oriented media elements with more traditional media-objects like texts and images that are embued with textual meta-data, within a generative virtual environment. One could make queries that bring different media elements into proximity in the virtual space e.g. the media elements described above might be brought into dynamic proximity and shed new light on a particular site and aspects of the cultural relationality of particular artifacts combining the most contemporary of sensing processes with older forms of representation.

Seaman's Insight Engine project enables searches across disciplines to bring textual and media materials into proximity via the linguistic analysis of meta-tags, stored and scraped texts. By bringing these different kinds of functionalities together in a holistic system, the new technology might enable exploratory relational approaches to differing forms of contemporary and historical data. Consider for example old maps, images and photos; oral histories; and earlier forms of mapping, along with media objects produced via contemporary sensing technologies, all brought into dynamic proximity via an intelligent query system. The goal of the overarching system is to enable intelligent meta-tag as well as corpus searches via statistical, semantic, and syntactic analysis to enable new forms of intellectual relationality to be defined by individual observers and/or groups of researchers, and/or via computational means—ai employment. This will also in time include intelligent pattern matching as well as new forms of visual and/or multi-modal intelligence. This later investigation can be considered an outgrowth of Seaman and Rösslers Neosentient research exploring new approaches to artificial intelligence and learning systems as coupled with multi-modal sensing systems.

As I unpack the system described above, I seek to do this in a different way to that of a traditional book chapter. I am interested in what I call recombinant informatics. Of course we know that computers can easily bring into juxtaposition different kinds of data and I could author a program that would allow me to combine and recombine these paragraphs. Historically this methodology has been explored more via combinatoric artworks, novels, poems and games. Yet here we explore in the service of creating new approaches to cyberarcheology through recombinant informatics.

For my Chapter, I will ask you as a reader to take an active role. Take any two paragraphs that are to follow and consider how they suggest a new research paradigm through their bridging. They will be intentionally short and modular so you can jump though them in a non-hierarchical manner. Of course this is antithetical to most book chapter publication but I think you will begin to see a parallel of this methodology to the system that the chapter itself is describing.

The goal of potential new technological system is to create an extensible intelligent network of multi-perspective knowledge production technologies, to be explored through the enfolding of multiple forms of mapping, polysensing [1][2], multi-modal data collection, storage, annotation, and insight production systems. The system will be designed to be accessed from multiple kinds of viewing systems, for differing kinds of viewing experience. I will discuss this below.

This New Field

As a media researcher one of the things I notice about the field of CyberArcheology is that it might better progress in the goal of creating new knowledge, by cross-pollinating differing modes of research. What kinds of system can we best author to accomplish this goal, mixing sensing system data with other historical forms? In particular this could be enhanced by articulating a network of intelligent relationalities[3] between actual sites, the media objects and technologies that represent them in differing ways, as well as through differing representations of objects that belong to earlier time periods. One can imagine a generative associational network that could function as a spatial visualization system dynamically linked to a relational database. Such a system could be explored

within a generative virtual environment. This environment would ostensibly enable the creation of intelligent juxtapositions between disparate media materials, thus potentially providing new insight into the "reading" of a particular media object, site, artifact, or historical notation. New notationas and/or observations could be added in an accretive manner. One imagines a virtual space housing maps from differing time periods, elaborate 3d Models, still photos, video, text documents, oral histories, etc. All of this material will be explored in a rhizomatic manner enabling any media-object to be juxtaposed with any other in a dynamic manner.

Relational Database

A relational database will function as a central storage system, housing these differing forms of sensed data, media-elements, media annotations, as well as specific forms of metadata. Yet, the connectivity of the system via the internet would enable differing researchers around the world to access it, adding in an accretive manner new data as well as new interpretations of that data. It will potentially be connected to multiple networked viewing spaces, i.e. a single screen presenting 3d data e.g. laptop or monitor; VR presented for 3D stereo goggles; and/or 3D immersive environment – e.g The Duke Dive[4], or semi-immersive environments in the DIG lab[5]; and/or the VR Dome as in SAT, the Society for Technological Arts, Montreal, Canada.[6]

Polysensing System

The polysensing system bundles together multiple sensors. Its goal is to explore bio-mimetic and bio-abstraction in terms of sensing over time, taking clues from human sensing. Here, we begin to be able to define computational time-based media code "objects" that have "consistent" attributes. One imagines this kind of sensing system at the cyberarcheological site in the future, and/or being employed by robotic learning systems that also function as part of the larger networked learning system. One idea about developing a deep knowledge of the context of the site, is to collect parallel streams of multi-modal sense data over time, and to begin to build up knowledge of a site much in the way a human does – employing

multiple senses. The programming of the system could potentially be modular in nature exploring "object-based code." Here the user of the system focuses the "Grammar of Attention" for the sensors that is easily set in motion by a remote observer via an "Emergent Intention Matrix,"— a dynamic menu system of differing options to help in defining the functionality of this multi-modal sensing system at any given time. Here the user selects interactively, differing kinds of functionality related to focusing the attention of the sensors. [7][8][9] One asks how would this be beneficial to extend the study of already existing artifacts? Here, new insights may be provided via new data where the interpretation and reinterpretation of that data becomes central. What can a series of machinic sensors tell us that we don't already know— new kinds of information about site that include temperature over time; qualities of light over time; qualities of sound over time; qualities of chemical reaction over time; qualities of spatial movement over time; qualities of larger flows of individual movements over time; and patterns of potential use of artifacts leading to new cultural understandings. These are just some of the initial ideas. Yet, given a particular time code as another stream of data, one can make correlations that link all of this different data at specific moments in time. This might contribute to the construction of potentially more holistic multi-perspective understandings.

Relational World Generator

One function in the system would enable a user to explore a Relational World Generator. [10] Such a system becomes a visual database query and perusal system, enabling users to select differing kinds of media objects to be brought into proximity either through interaction with the system via menu or via an entered, automated search query. This might bring into proximity images, maps, scans, 3d models and/or entire virtual environments, texts, oral histories, videos, key words, specific annotations and meta-data — essentially any form of media-object or process, to be juxtaposed with other forms of sensed data. The central aspect of this apparatus would be to function as a combinatoric associative network. Here users defining queries could call together objects using textual and image recognition potentials. In Seaman's, (along with Todd Berreth, and

Olivier Perriquet) Insight Engine, currently users can make a query and the system will do a search for relevant media objects based on semantic and statistical data, looking for other relevant media-objects. This draws on Arthur Koestler's notion of bisociation as discussed in 'The Act of Creation.' "I have coined the term 'bisociation' in order to make a distinction between the routine skills of thinking on a single 'plane', as it were, and the creative act, which, as I shall try to show, always operates on more than one plane…" "We learn by assimilating experiences and grouping them into ordered schemata, into stable patterns of unity in variety. They enable us to come to grips with events and situations by applying the rules of the game appropriate to them. The matrices which pattern our perceptions, thoughts, and activities are condensations of learning into habit. The bisociative act connects previously unconnected matrices of experience…"[12] I imagine expanding on this notion exploring polysociation, where one could choose multiple media objects and have the system look for other relevant media objects to be brought into proximity. It is this notion of virtual proximity and real-time perusal that may potentially enable new insights to be formed by users of the system. Using this system one will be able to articulate new forms of relationality, that might not otherwise surface. I will discuss later in the paper.

R-map — Room | Region | Relation Mapping

One potential is in developing a new technology for high resolution coordinated video of environments from many different chosen perspectives. Such a system would then provide a (navigable sequenced stills) video-virtual environment. The idea is that any detail in at the site might have an annotation made using this sub-system. The person doing the mapping of the site sets up the camera system, zooms in, focuses, and does a very slow power zoom with a consistent speed, recording many frames from different parts of the zoom. Such a zoom could be made at any angle from a central location. At any "virtual" location along the zoom, one could stop and add an annotation or link. These annotations would be searchable and would enable other media elements to be called into the Relational World Generator for intelligent juxtaposition, again, becoming part of the semantic and statistical analysis of text that has

been entered across the entire system.[12] One could also imagine such a system being mounted onto a robotic system, to enable the mapping of hard to reach environments, deep inside fragile and/or dangerous architectural spaces; and/or extreme environments e.g. radioactive or on other planets; or underwater sites, etc.

The Existing Tools of CyberArcheology

There are many types of CyberArcheological sensing tools that can be leveraged in the study of a particular site. Maurizio Forte at Duke's DIG lab in the program of the Media Arts + Sciences at Duke University, provides a description of his working environments:

> The project "3D-Digging at Çatalhöyük" started in 2009-10 as an on site digital experiment with the scope to record every phase of excavation in 3D using different technologies: laser scanning, computer vision and photogrammetry (image modeling). The final goal is to make the excavation process virtually reversible in a simulation environment at different levels, from laptop computers to virtual immersive systems.
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> In the last two years the project was focused on two main documentation levels : macro scale (all the excavations in the East mound, North and South shelters) by laser scanning ; micro-scale (the Neolithic house B89) by computer vision. In addition all the burials are systematically documented in 3D using image modeling techniques (Photoscan and Meshlab) and integrating all the data in GIS format (ArcGIS, QGIS).
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> Actually, the entire archaeological excavations on the East mound are totally recorded in 3D, paperless and georeferenced in the same virtual space. The project has also introduced 3D stereo visualization systems during the archaeological fieldwork in order to interact with 3D models along the excavation period. In 2012 the introduction of tablet PCs has actually reset all the digital drawing, field notes, mapping and 2D documentation in a complete digital format compatible with GIS and databases. More recently, a

> multidisciplinary team of Duke University has implemented all the virtual stratigraphy of a Neolithic house (B89) for the DiVE (Digital Immersive Virtual Environment) a fully immersive system of visualization and interaction. In the DiVE it is possible to virtually dig the house by browsing layers and archaeological datasets.[13]

The concept here is develop a next generation system that can include both metadata, and media—location–based textual annotations that can be "scraped" and put into the relational database such that one can do a statistical, syntactic and/or semantic analysis, and call up appropriate relational materials.

The Insight Engine

A related project that explores the use of statistical and semantic analysis is The Insight Engine. [11] This functioning computational system seeks to draw on my long history as a media researcher designing new forms of interface and qualities of interactivity, and to expand this via a strong interdisciplinary collaboration that bridges Neuroscience, Computer Science, the Arts and Humanities at Duke as well as through international collaboration. The Insight Engine is now expanding its potentials into the CyberArcheological arena. Such a project presents a multi-perspective approach to knowledge navigation and subsequent knowledge production. This research has been in the creation of a tool to empower insight production, distributed interdisciplinary team-based research and to potentially enable bisociational processes as discussed by Arthur Koestler in The Act of Creation (mentioned above). We are now in the process of making a 3d version of the Insight Engine to work in concert with the Relational World Generator.

If we reverse engineer differing research communities across multiple disciplines we can assume that many researchers undertake similar practices— reading papers, viewing diagrams, observing media-objects, exploring data sets, creating and viewing visualizations, annotating research materials, watching and annotating videos, as well as partaking in discussions among other activities. Interdisciplinary, crossdisciplinary, and transdisciplinary research also means crossing "linguistic" domains framing that

research. Here the generation of shared language (developing bridging languages) is essential. Could we make a new system that heightens the potential for insight and creative juxtaposition of essential ideas that cut across multiple research communities/domains that are central to CyberArcheology—including the Digital Humanities, Computer Science, Computational Linguistics, Imaging Science, Visualization creation, Historical research, the employment of differing viewing technologies, the internet of things, the distributed internet-based potentials of a unified system, differing potential media storage systems, as well as relational database set-up and management etc.

Searchable Mark-up for All Media Objects including Sensing System Data

If we could scrape textual data in conjunction with metadata in terms of each media-object input into the database i.e. if each media object was associated with an abstract, we could begin to be able to analyze and articulate how each media object could fall in relation to the others in the database. In terms of research, this means that a piece of text in an oral history might be brought into juxtaposition with an ancient map and/or a contemporary scan of the environment etc. Each media object carries a field of potential meaning, and use of the system would provide an ongoing meaning-summing through focused juxtaposition.[14] Alternately, pattern recognition systems could enable other forms of relational search.

Semantic, Syntactic, Statistical Analysis, as well as AI and Pattern Recognition

The potential is to scrape the text and use computational linguistic techniques including Semantic, Syntactic, and Statistical Analysis in order to find relevant media objects for juxtaposition as part of an automated query. Here the development and employment of a contemporary VR and/or sensing data mark-up language is essential, one that can be searched and accessed easily. One might also visually choose materials via the menu system. New forms of pattern recognition and/or vision systems might also be employed.[15][16] Otthein Herzog explores automatic content analysis and annotation

of still images, videos and sound for content-driven multimedia archiving, retrieval, and video abstracting.[17] This is also where artificial intelligence might become involved in CyberArcheology as part of a holistic networked system enabling researchers access anywhere connectivity is available.

A Compendium of Relationalities

I am very interested in defining a "compendium of relationalities." This could be helpful in the long run in terms of articulating relationalities of differing varieties of media-object in an automated manner. In terms of AI, an interesting initial attempt at parsing important categories of relationality was discussed by Joscha Bach in his book Principles of Synthetic Intelligence in terms of causal relations.[18] This could also be something that is done organically by having the system ask the user to explain the relationality between the media-objects they have chosen to explore, and add this into the database in a focused manner. This would also become part of the searchable/analyzeable text. Mentioned earlier, Ian Hodder's book *Entangled – An Archeology of Relationships between Humans and Things*, presents many "relationalites" across his entire text.[19]

Computational Learning Systems (do you really need so short paragraphs? Maybe you can consolidate some of them?)

Computational learning theory, neural networks, and machine learning (a subfield of AI) are areas that might become part of the Emergent Relationality System. Here data-mining becomes central to emergent aspects that arise through the functionality of the system.[20][21] Can we use learning systems to help us define relationalities we wouldn't normally come across? Can we also use learning systems to help us define categories on the fly? This becomes part of the goal set for the operational system.

Neosentience

Seaman and Rössler have been interested in ideas surrounding

learning systems for over a decade as explored in their book *Neosentience | The Benevolence Engine*.[22] The term "Neosentience" was coined by Seaman. It describes a new branch of scientific inquiry related to artificial intelligence. Seaman and Rössler's book explores the potential of creating an intelligent robotic entity in possession of a form of sentience similar to that of a human being. The juxtaposition and re-juxtaposition of many micro-chapters in the Neosentience book enables one to reflect on new research possibilities and approaches— what Seaman calls Recombinant Informatics. Seaman and Rössler suggested a pragmatic set of benchmarks to articulate Neosentience— We consider a Neosentient robotic entity to be a learning system that could exhibit well-defined functionalities: It learns; it intelligently navigates; it interacts via natural language; it generates simulations of behavior (it "thinks" about potential behaviors) before acting in physical space; it is creative in some manner; it comes to have a deep situated knowledge of context through multimodal sensing; it exhibits a sense of play; it will be mirror competent and will in this sense show self-awareness. In the long run such a robotic learning system could be networked with the other technologies discussed above. It could actively employ a polysensing environment (discussed above) as part of its own synthetic sensing system. One could imagine implementing aspects of the Neosentient paradigm in our Emergent Relationality System, adding new functionality over time.

Future Approach – The Light Data Domain

Seaman has been in discussion with Tuan Vo-Dinh, PhD, Director, Fitzpatrick Institute for Photonics, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, and Professor of Chemistry at Duke University, about a hypothetical technological approach to networked communication systems. As one surveys the field of contemporary sensing, communication and computational research, one sees a number of different research areas that each explore the use of light as a process-related vehicle. If we begin to articulate connectivity between differing research areas, does this suggest a new holistic paradigm shift toward the use of light as a vehicle for multiple functionalities to be housed in our

holistic system? Here different modalities of light-oriented technologies may potentially function in concert to achieve a cybernetic cycle flowing from multi-modal sensing system to computational system to memory and database systems to visualization systems, then back to the observer, who programs, designs, and interacts with the systems within a dynamic distributed network of intra-actions. Where some have felt that we have reached the end of Moore's Law, might the use of light in the light of these new technologies, function as a means to transcend current electron-based methodologies? Does this suggest a radical shift from the electron to the photon as a contemporary physical propagation mechanism for data? Why would this be of interest? What are the unique qualities of light that play into this paradigm shift? Vo-Dinh and Seaman call this holistic network of technologies and processes the *light-data domain*.

Conclusion

I have discussed at length the creation of an extensible intelligent network of multi-perspective knowledge production technologies, to be explored through the enfolding of multiple forms of mapping, multi-modal data collection (polysensing), storage, annotation, text analysis, and insight production systems. Of course this is still just a hypothetical network, but I believe this to be a promising area of future investigation for the field of CyberArcheology. Here the dynamic employment of new sensing systems as they are brought together with database search methodologies, and new viewing mechanisms, may contribute to new knowledge and insight production. I will here focus the multiple ways sensing will be employed in this holistic system.

1) differing forms of machinic sensing will be employed on the site, this includes currently used systems for scanning and mapping archeological sites.
2) a video VR mapping system Seaman calls R(map) – room/region/relation mapping that includes dynamic annotation will be developed, with the potential of scrapable text and/or pattern recognition capabilities.
3) A poly-sensing system which encodes multiple streams of sense-oriented data over time, in parallel, will be developed.

This is to draw on the abstraction of human sensing as it is implemented via a multi-modal machinic sensing system. The notion is to develop "code" objects that help the system develop new forms of deeper context awareness over time. This may also enable new forms of dynamic correlation of data from differing sensed perspectives.

4) Seaman and Rössler's Neosentient research presents a learning system that integrates poly-sensing data with new approaches to AI and learning systems.
5) The focus is on an integrated holistic system that enables the various forms of sensed data to be housed in a relational database and called up in an intelligent manner such that it can be juxtaposed with other "sensed" data (or other data in general) though differing linguistic search methodologies (semantic, syntactic, and statistical) as well as pattern-oriented approaches to discerning and categorizing the data.
6) The sensed data will be made available for viewing/listeniing in a interactive generative virtual environment and/or via other forms of viewing apparatus (laptop/ipad) etc. Thus a cybernetic loop will be entertained that moves from integrated sensing, to storage, to search, to categorization, to dynamic juxtaposition in viewing, to additional intellectual input/analysis and or the creation of additional dynamic links that future users and collaborative researchers can explore.
7) In this holistic system, many different kinds of researchers can work together juxtaposing differing forms of "sensed" media objects that are housed in the system within an accretive distributed learning environment.

This holistic Emergent Relationality system integrates many technologies that are currently part of CyberArcheology, with new integrative technologies, in an intelligent manner that may potentially contribute in the long run to new forms of deep contextual historical understanding.

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