Mediterranean Archaeology and Archaeometry, Vol. 15, No 3,(2015), pp. 313-332

DOI: 10.5281/zenodo.33832

DIGITAL TECHNOLOGIES AND TRENDS IN CULTURAL HERITAGE

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Received: 20/09/2015
Accepted: 01/12/2015
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ABSTRACT

The New technologies alter our lives and the way in which we perceive it beyond the imaginable. This further ulterior over is the point in space-time in which coalition of science, technology and art openly combined for the 3rd Cultural Revolution, and for environmentally sustainable abundance. However, this time, the "Beyond" not only explores the dynamic 3D screen, it moves on from the bits to the atoms and incorporates 3D-printing and digital cloud-distribution which combined to relevant scanning or photographic technologies create a virtual environment as a real world. We are entering the central source for current and emerging trends in cultural heritage informatics with new disciplines, sub-disciplines and terminology to emerge. Virtual, cyber-archaeology and cultural heritage to cyber-archaeometry, are matters that are tackled. The virtual archaeology case studies, over the World, as a result of advanced technology emerging from computer sciences, however, stress the naturalistic methodology, challenges digital reconstructions and serious games. There may provoke also harassment and emergence of fundamental hermeneutical questions which serve as the basis of a synoptic and synthetic philosophy that combines art and science corresponding to classical techne, logos and ethos.

KEYWORDS: *archaeology, cultural heritage, cyber, digital, virtual, 3D, archaeometry, museums, world wide web, interaction, gamification, augmented, SfM*

1. INTRODUCTION

In 1999, about nine years after the invention and public domain of the WorldWideWeb project[i] Levy et al (2001) made a commitment to 'go digital' by recording all field measurements on excavations in Jordan related to the role of ancient metallurgy on social evolution. That was the start of a growing field of 3D visualization. This first application was referred to as on-site digital archaeology (OSDA) 1.0 (Levy et al., 2001). A summary of the most important new developments in OSDA 3.0 that make it a much more versatile system (Fig.1) takes advantage of both off-the-shelf technologies and also includes new computer programs and hardware developed specifically to solve archaeological/cultural heritage problems that face researchers working around the world today.

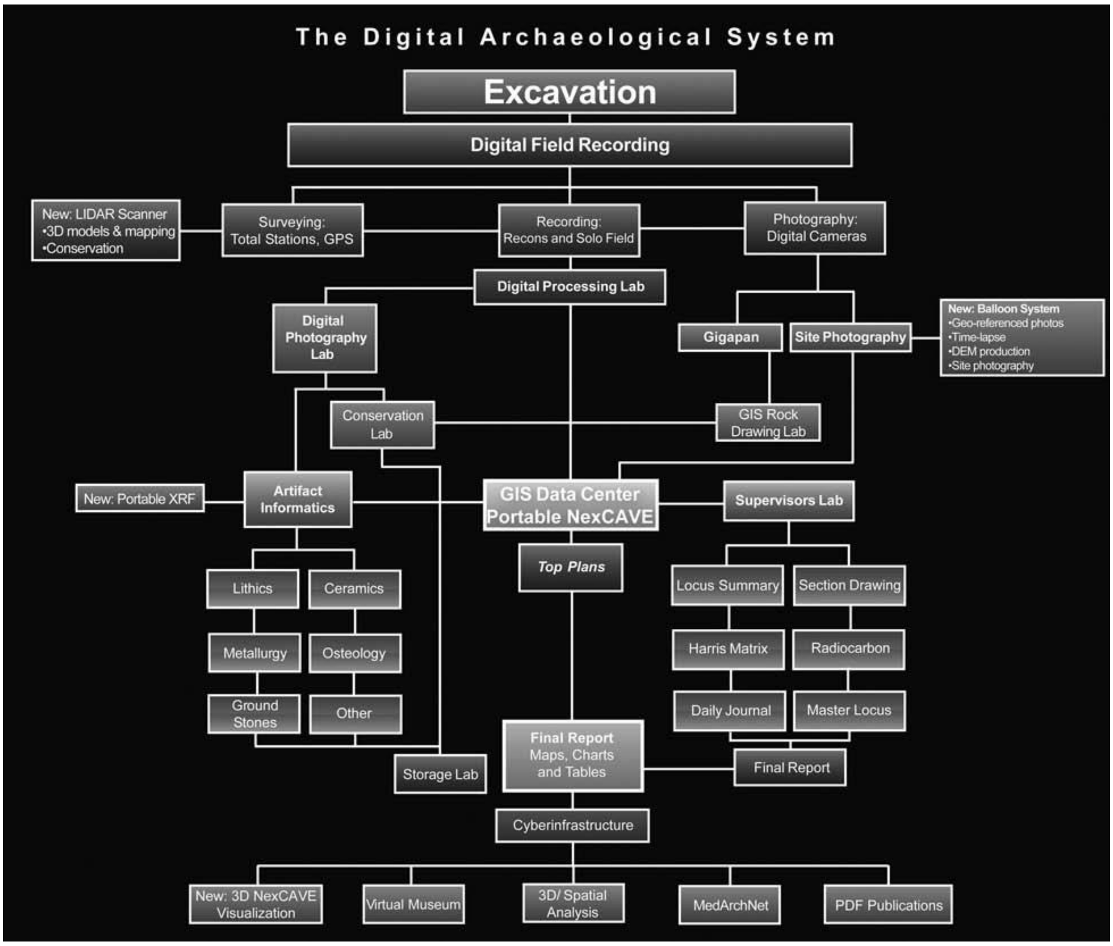

Figure 1. A block diagram that describes the On-Site Digital Archaeology 3.0 system with new elements highlighted and discussed in this paper: LiDAR mapping, helium balloon airborne photography, StarCAVE, NexCAVE, Artifact Informatics, and cyber-archaeology represented by the Mediterranean Archaeology Network (MedArchNet).(after Levy et al, 2010)

The Digital archaeology appears together with The Project that was the first public available information website to connect and share documents on personal computers via the internet (published by Tim Berners-Lee at CERN in 1991 who used HTML 1.0. Its first web address was http://info.cern.ch/hypertext/WWW/TheProject.html, which described the WorldWideWeb project). The web turns 24 this year, and while national libraries, archives, universities, and other cultural heritage institutions have been archiving the web since the late 1990s, the early web, the first website from World Wide Web[ii] co-inventor Sir Tim Berners-Lee, created in 1991. The website featured at Digital Archaeology is believed to be the earliest available copy, from 1992.

The CD-ROM of course use of digital record in arts and humanities has been initiated earlier (e.g. the Perseus Project, Perseus Digital Library planed by 1995 at Tufts and issued in 1992 by Yale University Press, TLG). More digital publications in CD or online have been developed since then, that have contributed a great deal in the investigations of hu-

manities, the cultural heritage being a major issue (Sabharwal, 2015).
In the present article we focus on the new digital technologies, multimedia technologies, the trends but some emergent skepticism, in the relevant studies of tangible cultural heritage.

2. ONLINE MUSEUM VISION OF CULTURAL HERITAGE: QUESTIONING THE PROJECT

The questioning on the electronic processing and presentation of museum artifact collections and monuments with the application of new technologies and in particular the potential of the Internet has given rise to a new turn in discussion started from the late 90s onwards. The interest shifted to the relationship of the museum with the Web (WWW), the possibilities it offers for redefining the role, the importance and function of museum institutions. New terms were introduced to describe the presence of real, 3D museums on the Internet, but also in the emergence of a new class of museums, the exclusively "online", i.e. those not connected to a real museum environment, but exhaust their existence in cyberspace. Then, issues were posed related to the "essence" of the museum, its relationship with knowledge and material culture, its role in society. We may summarize the concerns expressed and remain under negotiation on a series of questions (Dascalopoulos & Bounia, 2008; Cameron, 2006; Barrett (ed), 1992).

- *The presentation of the museum on the internet undermines or strengthens traditional perceptions of the primacy of material culture, the authoritative and authentic of works of art and museum visit?*
- *Have the visitors more freedom to engage with the museum and its contents, or during their web visit are the traditional relations of power of the museum with visitor been confirmed?*
- *How digital collections affect the treatment and understanding of the museums?*
- *What happens when ordinary people start producing content of museums on the internet by adopting the role of the curator?*
- *Is it finally coming on a comprehensive, global and democratic conception about the museum?*
- *What is the role of museums in the internet for the creation of knowledge?*
- *Do museums in this form encourage the active learning or just perpetuate passivity inviting users to "press buttons" on selected images?*
- *How the educational role of the museum is associated with the consumption, literally and figuratively, of objects accomplished through the digital presence of museums?*

The issues and challenges posed by the presence of museums on the Internet both for actual and for digital agencies are issues that seek for solutions but also developing initiatives of another aspect. Thus, it is strengthened the new concept against entrenched view, that museums are not gathering pools for presentation the material objects but nucleus of gathered knowledge and information.
By establishing the new perception about digital archeology with computer sciences, archaeometry, theoretical anthropology and sociological bases, the virtual museums (VM) emerge as complex entities that raise new issues and bring the museum facing new challenges. VMs do not stop to strengthen the dialogue with the subject and the landscape that contributes to a holistic approach and epistemological analysis that assists and the so neglected but essential value of self-knowledge.
Answers to the above challenges and concise questions are not easily achieved. However, we could speculate that the Internet or digital museum and the virtual representation (virtual reality) under strict harmonization with the excavation and written historical data gives intelligible knowledge as information which is not lagging from the knowledge obtained from the study of ancient texts and the virtual reconstitution of archaeoenvironment and society. Moreover enhances subtle aspects of the whole set that integrates them. The fanciful effect imparted by the digital presentation is not of less value from its analogue in real space, although in the latter often the dramatic deterioration of the environment and the broader landscape is observed, something which introduces misleading information of images where the visitor hardly ejects to hire those truly details of space-time.

Moreover, the inability of the State to give the visitor a short time on the plethora of museum collections and monuments and all the rich information of ancient civilizations, the world wide web (WWW) presentation achieves and gives the visitor the freedom to special options for in situ visit - a (relative) advantage of the idea of locality, the inner emotional kicking (co-movement) and unique stimuli, which are subjected to the five senses from the perception of ancient environment and objects.

The development of good practice in archeology is also the result of internal self-reflection within the same discipline itself, as well as, the positive (evaluated) development from other disciplines of human evolution. Regarding, for example, the "new" method of "reversed archaeology”, which is a missing link to the cultural heritage that refers to the integration of archeology in spatial planning and the associated social and democratic offer, new technologies could be well placed for any planned project (Deeben et al., 1999; Chirikure, 2012). (See, articles in the journal Heritage & Society, vol.5, no.1, 2012).

Reverse Archaeology propones archaeological knowledge as a source of inspiration for spatial planning design, aiming to give a practical output to research paid by developers when an area is affected by archaeological resources not suitable for in situ preservation and public enhance.

Nevertheless, some positive points asserted by Reverse Archaeology, such as decision-making process and stakeholder participation, are both critique commented and encouraged for further work moving the discussion (Colomer, 2012), but the contribution of virtual archaeology is another extra positive element to reverse archaeological projects. In any case, harmonization of all "interested players' in cultural heritage is essential if the discrete members are defined, as well as, their roles in the study, promotion, management, exploitation, accessibility without social exclusivity, the sustainability and rational sustainable economic development - from local and domestic society, the visitors, archaeologists, scientific experts, private institutions.

In addition to the above, a particularly critical issue is the modern fears and weakness for security from negative phenomena promoted by the globalization for the survival and preservation of local traditions and cultural resources, brazenly violating international conventions of UNESCO 2003, 2005 see, (http://portal.unesco.org/en/ev.phpURL_ID=12025&URL_DO=DO_TOPIC&URL_SECTION=471.html); Bauer & Haines eds, 2012). In these social phenomena the attempt must be resumed by every scientist and every citizen of a country that is also citizen of the World, by NGOs, by state bodies and exercise of particularly intense cultural diplomacy upon international co-decision making.

3. MULTIMEDIA TECHNOLOGIES AND SCEPTICISM

New technology of display with motion and representation refers to the rapid development that took place in recent years in the computer technology and has really given a new push to the cultural multimedia technology through flexible metadata, multimedia applications and complex systems of VR (virtual reality), thus covering a wide range of services.

This technological progress has brought at the same time a significant reduction in the total cost of these applications, which constituted in the past a significant disincentive factor to further development and dissemination. The objective aim of technology was, from the outset, the development of realistic 3D representations, which may provide the user with interactive features through which one may make actions similar to those that characterize the real world. In the field of archeology, but also more generally to the cultural heritage, these technological advances have found lately a fertile ground that embedded the term to archaeology (virtual archaeology).

With tools from various branches of IT modern information technologies is presented in the field of promotion of Antiquities namely the development-use of multimedia technologies services and virtual reality. It has been outlined the regulatory framework of legal and safe enhancement of antiquities, with emphasis on copyrights that accompany their emergent digitalization and their protection technologies. The Virtual Reality is distinguished by three main features*: a) the display in three dimensions, b) interactivity, and c) the possibility of the user's immersion in the virtual world.* (Metha, 2001).

There are many cases where virtual archeology has been implemented although it is under rapid development in most countries, in others (e.g. in Greece) lacks systematic planning of public cultural heritage and public museums and museum collections, and the use of scientific results that highlight them is lacking.

Also, use of astronomical computer programs and development of new multimedia modeling techniques as a means to better understand relation of monument orientation and architecture with celestial bodies (archaeoastronomy) and thus obtain a sphaerical perception of the astronomical events has been approached in a variety of ways. (http://www.stonehenge3d.co.uk/index.php?option=com_content&view=article&id=47&Itemid=5).

The University of Groningen has developed unique 3D models software with applications in Cubes (Reality Cube) and theaters (Reality Theatre) with stereoscopic virtual reality 3D screens with uses of shutter glasses (Shutter Glasses), as well as films with representations of everyday life in ancient times, in the fields of landscape architecture and museums of historical and archaeological content. These activities have great impact on the local economy through cultural and educational tourism (site visit September 15 2015:
(http://www.rug.nl/society-business/centre-for-information-technology/research/hpcv/projects/virtuele-archeologie_-van-giffen-in-3d).

Figure 2. Representation of hut of ~500 BC by the excavations of prof. AE van Giffen (1884-1973) and is a snapshot of a virtual representation of the film about daily life in the village. Implemented by the Center for Computational High Technology and Visualization (HPC/V) of the University of Groningen (http://www.rug.nl/society-business/centre-for-information-technology/research/hpcv/vr_visualisation/art_ exhibitions/van_giffen/vangiffen_1_600.jpg)

Such a cultural model not only deals with concrete material from cultural remains, but that UNESCO describes it as "intangible policy "and this culture are the actual or old social traditions practice, practice of arts and ceremonies (Champion, 2005). In the investigation of how digital media can lead to modern interpretation techniques of the past more is used the relevant descriptive term digital cultural heritage. This is mostly used instead of most common virtual culture or virtual archaeological heritage which have become recognizable with visual simulations of the material culture (Roussou and Drettakis, 2003).

The term digital cultural heritage is adopted as a well-accepted terminology for the determination of digital methods of heritage within a historical context. Roussou and Drettakis (2003) suggest that it may not be necessary the construct photographic effigies of the region, arguing that in archeology, building a credible and convincing environmental landscape is much more relevant than a photographic accuracy.

One of the risks in photorealistic archaeological models is that they can be of optical quality, and the risk to lure viewers in an uncritical acceptance of what is ultimately the separate artistic interpretation.

As Gillings (2000) states, an over-reliance on simulations may also remove its past historical and archaeological content. Regarding the limitations of high resolution optical models he notes that "*the object of analysis is the building itself as a sterile architectural shell, stripped of the world and its self-constructions (do it yourself, bricolage) of daily habits»* (Gillings, 2000).

In the recent past designers of cultural heritage expressed the importance of interaction. As shown in literature, the failure of previous visualization models has to do primarily with low analysis or with insufficient technological standards, but rather of inappropriate design and the low degree of interaction with the user.

A popular heritage approach considers the end user as the prominent aspect of creating an exciting environment. In other words, the issue is not only how the environment looks like or how faithfully simulates original, but what is critical and what it does and how the user receives the experience of cultural past. In this way, the cognitive process of thinking of user and the cultural subjectivity, become as a considerable factor in the design process. If we consider the interaction as a vital point in the design of heritage, it is useful to categorize the different interactive levels with the user.

Mauricio Forte (2000) describes the simplest implementation of interaction at the first level, as passive conceivable interaction where navigating in the digital space takes place without causing changes to the environment. Examples of passive mental interaction includes walking and flights where the user can see three-dimensional or with Virtual Reality panoramic world from different angles. This level of interaction was what the most common in digital heritage and archaeological reconstructions, but was proved as frustrating for many users who aimed at a more dynamic engagement with the content (Champion, 2003).

A second level of interaction described by Forte as active mental interaction is surfing that takes place with adaptive switching between the environment and the events. This may lead to interaction with objects or interconnection devices Haptic (= technology which interfaces the user via touch by applying forces, vibrators and / or motions to the user). However, as long as energetic cognitive interaction processes cause a more active participation by the user, there is a general consensus that the content stays overly didactic, offering homogeneous justifications for the past which trivializes and fragments its historical significance.

A third level of interaction that is missing from the classification of Forte can be considered the vulnerable dimension associated with game engines and immersive environments. An example of this is where the movements of user cause changes in the environment. Such materialized dimensions can add a quantitative dimension of tension in the quality of experience that moves beyond the re-projection and the visual effects. The user can be dynamically involved in the show or come face to face with the past. This can take the form of an archaeological reunion – a type of built in forms of interaction in which the user investigates archaeological issues rather be the recipient of pre-processed historical summaries. Archaeologists collect a large number of digital data from the globe however they lack the tools for synthesis, integration and cooperative interaction to support recovery processes and interpretation.

The software TeleArch aims in this synthesis of various data sources and provides interactive tools in real time (real-time interaction) for communication at a distance within a common virtual environment. The framework also includes audio, 2D and 3D video streaming that facilitate remote users. Several examples on this are shown on the interaction with 3D models and geographic information systems (GIS) (Kurillo & Forte, 2012).

Finally, information technology has progressed to further applications in archaeology. Hence the question: why the archaeological artifacts are as shown they are, the relationship between form and function is investigated. New ways of studying are proposed, of how past behavior can be ascertained by examining archaeological observable parameters at present.

In any case, we take into account that there are also "invisible elements" that are inhered and characterize ancient artifacts and materials (i.e. constitutive information based on mass spectrometry, chronology based on radioactive decay, etc.). The information should make us aware of the multi-functional object properties are multivariate in nature: size, which refers to the height, length, depth, weight and mass, shape, and form, referred to contouring geometry and volume, structure, that refers to micro-topography (surface roughness, ripples, and installation) and visible appearance (color changes, brightness, reflectivity and permeability) of surfaces. And finally material, meaning the combination of separate components, and properties that form the whole set.

With the exception of the data of the material, other relevant data of a functional logic have been described traditionally rather in vague terms, without taking into account the benefits of quality measurement of shape, form and texture. The logic on the functionality of archaeological items retrieved from an archaeological site requires interdisciplinary study, which can range from reconnaissance techniques used in the computers and robotics in learning processes representative and reasonable in artificial intelligence.

One approach is to follow current computational theories of perceived image of the object and improve the way archeology deals with interpretation of human behavior in the past (functionality) from the analysis of visual and non-visual data, whereas the optical appearance and even the ingredients typically only restrict the way It can be used an object, but which never is defined holistically (Barcelo & de Almeida, 2012).

Finally, apart of the material culture (and intangible cultural heritage), interdisciplinary approach of new technologies and archaeometric methods which contribute effectively and more often is a necessity, in revealing the internal details of an artifact or monument, for becoming comprehensive, anticipate their own virtual representation. The link connecting archaeology with the results but also the instrumentation and operation of archaeometrical methods has not been adequately developed. Virtual labs work only recently emerge as dynamic proposals to the virtual archaeology and will form the future of research and applications in the next few years.

4. DIGITAL ERA IN ART & ARCHAEOLOGY: TERMS & DEFINITIONS

4.1 Digital Technologies

The Digital Revolution, known as the Third Cultural Revolution, is the change from analog, mechanical, and electronic technology to digital technology which began anywhere from the late 1950s to the late 1970s with the adoption and proliferation of digital computers and digital record keeping that continues to the present day.
(http://web.archive.org/web/20081007132355/http://history.sandiego.edu/gen/recording/digital.html).

The term implicitly, also, refers to the sweeping changes brought about by digital computing and communication technology during (and after) the latter half of the 20th century. Analogous to: a) the Agricultural Revolution (from hunter-gatherer to food producer, ~10,000 years ago)[iii], and the b) Industrial Revolution (late 19th c), the c) Digital Revolution marks the onset of the Information Age or Cyber era. All transitions are associated by social changes.

Figure 3. An authentic ancient Egyptian painting from the tomb of Nefermaat showing the trapping of birds and harvesting crops ~2700 BC Cairo Museum (The Yorke Project) (https://commons.wikimedia.org/wiki/File:Maler_der_Grabkammer_der_Itet_002.jpg)

Central to this revolution is the mass production and widespread use of digital logic circuits, and its derived technologies, including the computer, digital cellular phone, and the Internet.

4.2 Cultural Heritage

It is the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations. Cultural heritage includes tangible culture (such as buildings, monuments, landscapes, books, works of art, and artifacts), intangible culture (such as folklore, traditions, language, and knowledge), and natural heritage (including culturally significant landscapes, and biodiversity). The deliberate act of keeping cultural heritage from the present for the future is known as preservation or conservation (though these terms may have more specific or technical meaning in the same contexts in the other dialect) applying various methods from the interdisciplinary field of conservation science, archaeometry[iv] / archaeological sciences and architecture. The additional act of reconstructing cultural heritage is known as restoration and digital reconstruction (in time and space). It is the latter act with which we are concerned.

4.3 Virtual Archaeology

Virtual Archaeology was coined as the use of digital reconstruction in archeology (Reilly, 1990). The Virtual Archaeology was mainly visual, static, with graphics and orientated to photorealism. Recently, new approaches have been added using various interactive practice. The 3D modeling is a very useful practice for the identification, monitoring, conservation, restoration and enhancement of archaeological objects (Fig.4). In this context the 3D computer graphics can support archeology and heritage policy, offering scholars a "sixth sense" for the understanding of the past, as it allows them almost to live it (DeFanti, 2010).

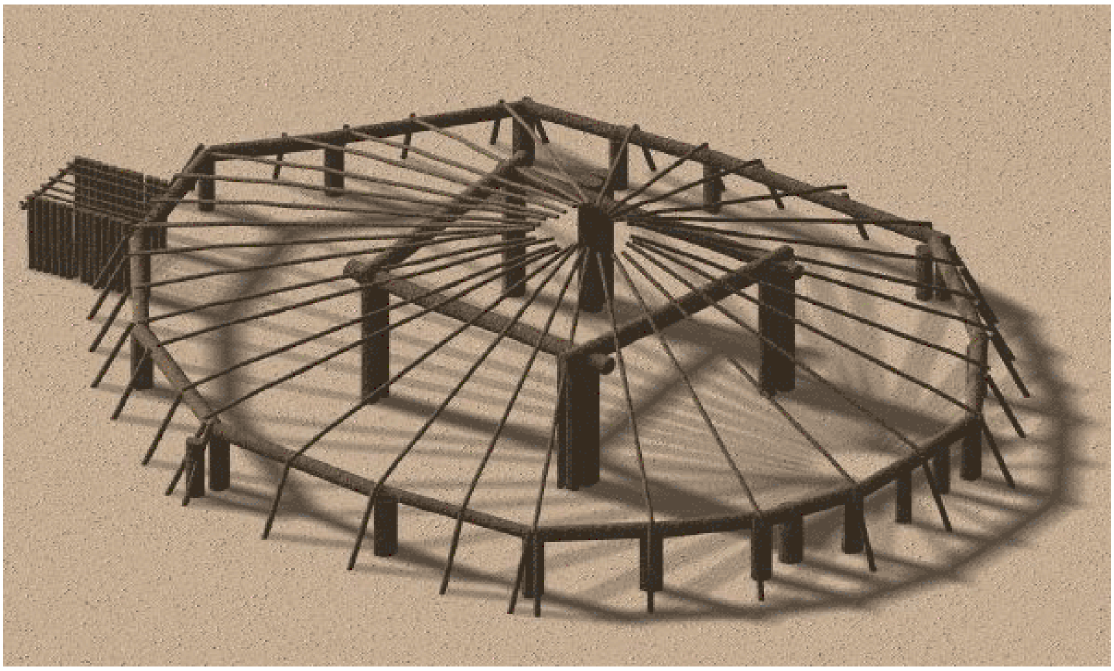

Figure 4. A JPEG image of a Form-Z model extruded from an AutoCad representation of the floor plan. It concerns settlement of Native American tribes in the Dakota region Note the support beams are irregularly spaced and doubled up in some places. (http://fishhook.ndsu.edu/lodge/)

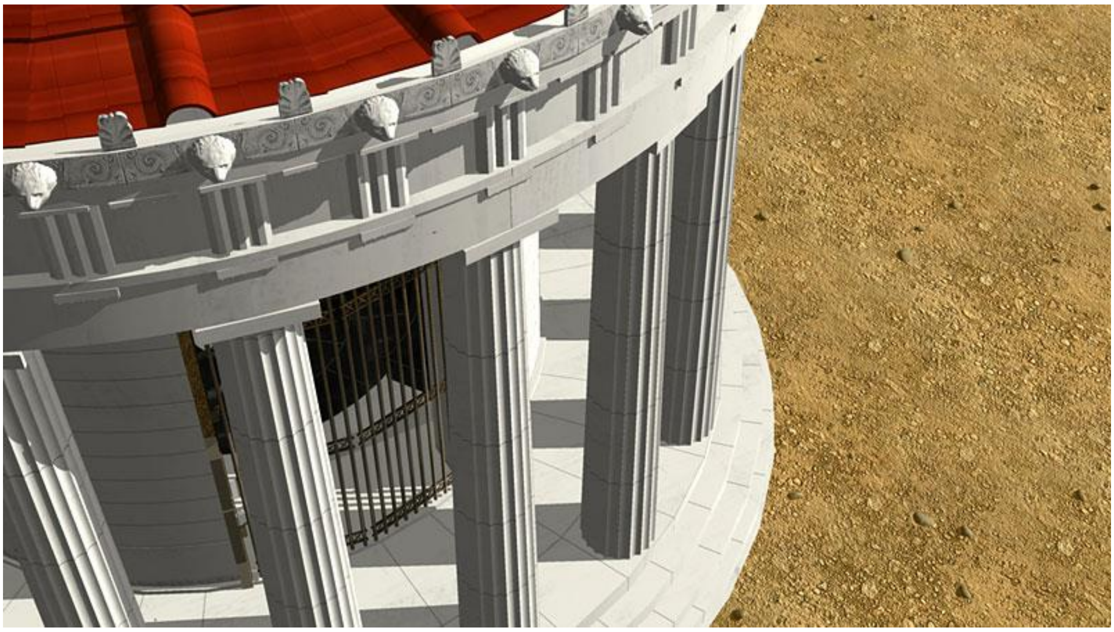

Figure 5. Attempted 3D reconstruction of part of the circular tholos at Delphi (source: Emily VerMeulen, Coastal Carolina University;http://www.coastal.edu/ashes2art/delphi2/marmaria/tholos_temple.html)

VA is computer-generated simulation of reality with physical, spatial and visual dimensions. This interactive technology is used by architects, science and engineering researchers, and the arts, entertainment and video games industry. Virtual reality systems can simulate everything from a walk-through of a building prior to construction to simulations of aircraft flight and three dimensional computer games.

Immersive technologies and virtual reality are powerful and compelling computer applications by which humans can interface and interact with computer generated environments in a way that mimics real life sense engagement. Although mostly known for its application in the entertainment industry the real promise lies in such fields as medicine, science, engineering, oil exploration, data visualization and the military to name just a few. As 3D and immersive technology becomes more integrated and available for a wide range of applications. It requires well-designed user interfaces and innovative content for the next generation of computer games and integrated technology like mobile devices, distributed web systems and desktop applications.

4.4 Cyber - Archaeology, CA

The past cannot be remade, but could be simulated. The CA is the process of simulation and reconstruction of archaeological finds or cultural materials. The archeology of the third millennium is able to process, interpret and transmit much more data and information relative to the last two centuries (Levy et al., 2012).

CA is the digital management of much partial information in the field. It is not necessarily visual, but dynamic, interactive, complex, autopiitic (self-organized) (Maturana & Varela, 1980) and not necessarily oriented to photorealism.

The rapid development of cyber archaeology has led over the past 3 years, to the expansion of informatics tools applied to archaeology and art and to the establishment of new centers (e.g. Center of Interdisciplinary Science for Art, Architecture and Archaeology (CISA3) at UCSD's California Institute of Telecommunication and Information Technology (Calit2), a collaboratory framework has been established facilitating joint research between archaeologists, computer scientists and engineers.

4.5 Cyber-Archaeometry, CAm

Cam is the digital IT process of simulation, restructuring & management of archaeometric processes from the field of natural sciences in relation to material culture, investigated variously (dating, prospection, analysis, technology, provenance, archaeoastronomy, etc.), either as optimum recruited image or as targeted research quest (Liritzis et al, 2014).

If you see this cyber era as a retrospective concept, we have to compare the two approaches in the development of digital archaeometry i.e. from archaeological procedure (processualism) to post-procedural thinking. But in order to achieve the analysis of hybrid forms of both these approaches, it requires procedural tools (i.e. statistical analysis and quantitative methods in different fields, mathematics, geography, archaeometry, anthropology, archeology and related disciplines). The virtual CAD of all these disciplines is an example of the emergence of cyber-Archaeometry. (See, below Simulation of a petrographic (optical) microscope).

4.6 Virtual Environment, VE

The environment created on a PC to mimic the real world (Fig.6). It allows large extended interactions between users and the training and laboratory materials, even from their own space. The use of 3D characters in game environment results a catchy learning process.

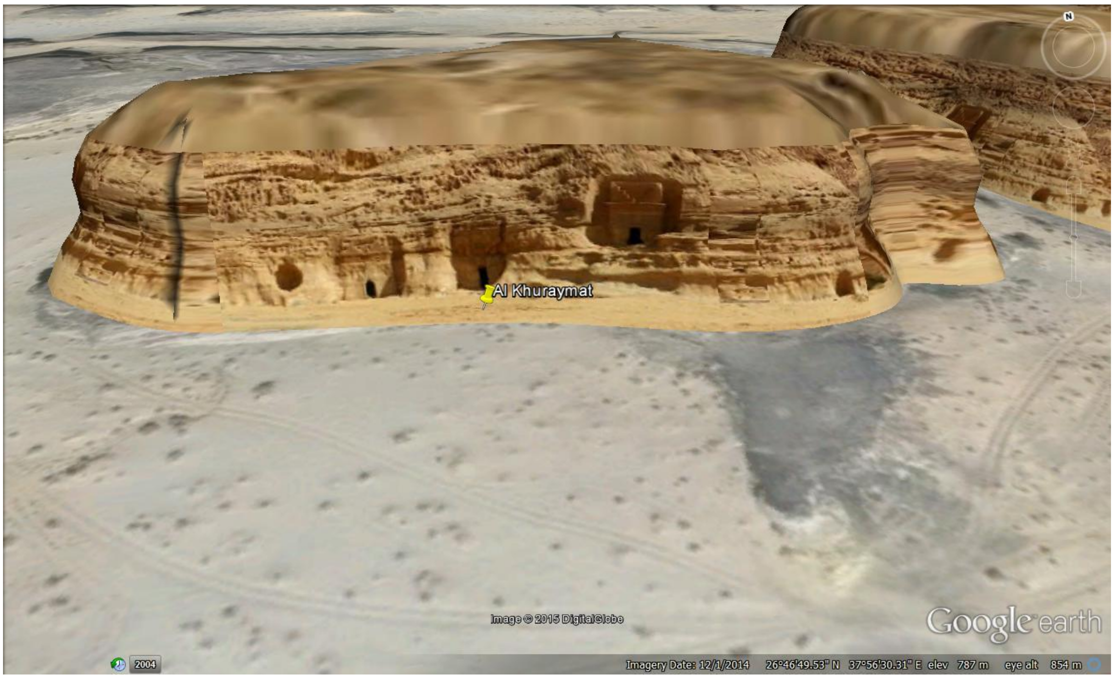

Figure 6. Nabatean rock carved tomb at Al Khuraymat, Saudi Arabia, general view (Google map).

4.7 Virtual Reality, VR

Virtual reality is a more specific form of a virtual environment that provides to the user a sense of presence. Presence can also be viewed as the feeling of "immersion" of the user in the virtual environment. Immersion offers conditions promoting the feeling of presence (O'Neil and Perez, 2006).

Figure 7. Shot from the Project "Synthesis": Synthesis of Ideas, Forms and Tools for Cultural and Artistic Education. (http://synthesis.ipet.gr/portal/applications-gr/ (G.Pavlidis pers. Comm.).[v]

4.8 Massively Multiplayer Online World MMOW (Virtual Worlds)

A virtual world or massively multiplayer online world (MMOW) is a computer-based simulated environment (Bartle 2003; Aichner & Jacob, 2015) populated by many users who can create a personal avatar, and simultaneously and independently explore the virtual world, participate in its activities and communicate with others. These avatars can be textual, two or three-dimensional graphical representations, or live video avatars with auditory and touch sensations in general, virtual worlds allow for multiple users.

Massively multiplayer online game (MMO or MMOG) is a multiplayer video game which is capable of supporting large numbers of players simultaneously. By necessity, they are played over a network, such as the Internet. MMOs usually have at least one persistent world, however some games differ. These games can be found for most network-capable platforms, including the personal computer, video game console, or smart phones and other mobile devices.

MMOGs can enable players to cooperate and compete with each other on a large scale, and sometimes to interact meaningfully with people around the world. They include a variety of game play types, representing many video game genres. Some MMOGs have been designed to accurately simulate certain aspects of the real world. They tend to be very specific in various aspects of life and technology and has been used in cultural heritage assets too.

Virtual worlds are a powerful new tool for teaching and learning that presents many opportunities, but also some challenges. A virtual world is *"a synchronous, persistent network of people, represented by avatars, facilitated by computers"* (Bell, 2008). This can be applied to cultural assets dynamic virtual reconstruction.

4.9 Augmented Reality, AR

Augmented reality is the opposite of the closed world of virtual spaces. It is a technology that is primarily used in mobile phones and tablets. This technology allows live viewing of a natural environment but whose reality is augmented by viewing information and images of people or places designed through a computer. This is achieved by computer-generated sensory input such as sound, video, graphics or GPS data. Augmentation is conventionally in real-time artificial. Information about the environment and its objects can be overlaid on the real world (Graham et al., 2012; Rolland et al., 2005).

Figure 8. Augmenting Tholos Delphi.

4.10 Immersive Archaeology

Immersive technology refers to technology that blurs the line between the physical world and digital or simulated world, thereby creating a sense of immersion.

Immersion into virtual reality is a perception of being physically present in a non-physical world. The perception is created by surrounding the user of the VR system in images, sound or other stimuli that provide an engrossing total environment.

Immersion can also be defined as the state of consciousness where a "visitor" or "immersant" awareness of physical self is transformed by being surrounded in an artificial environment (Popper, 2005; Nechvatal, 2005, 2009; Paul, 2008).

The following hardware technologies are developed to stimulate one or more of the five senses to create perceptually-real sensations (Table 1)

TABLE 1. Simulation of senses.

Vision	Auditory	Tactile	Olfaction	Gustation
3D display Holography Head-mounted display Fulldome	3D audio effect Surround sound	Haptic technology	Machine olfaction	Artificial flavor

Software interacts with the hardware technology to render the virtual environment and process the user input to provide dynamic, real-time response. To achieve this, software often integrates components of artificial intelligence and virtual worlds.

Many universities have programs that research and develop immersive technology. Examples are Stanford's Virtual Human Interaction Lab, USC's Computer Graphics and Immersive Technologies Lab, Iowa State Virtual Reality Applications Center, University of Buffalo's VR Lab, and Teesside University's Intelligent Virtual Environments Lab. (Weinberger, Sharon, "Spooky research cuts: US intelligence agency axes funding for work on quantum computing", Nature 459, 625 (2009), 3 June 2009; Forte 2010).

4.11 Structure from Motion (SfM)

A technique used from the field of computer vision called Structure from Motion (SfM) does the first stage of 3D reconstruction. Structure from Motion refers to the method of extracting a 3D structure from many overlapping digital images. Beginning in the 21st century, SfM emerged as a new photogrammetric technique for 3D reconstruction that uses robust computer vision algorithms that automatically detect matching features in images (Lowe 2004; Wu 2007; Furukawa and Ponce 2007; Hartley and Zisserman 2003).

Rather than standing in a fixed position and capturing 3D data, SfM algorithms[vi] use a change in camera position for each image to find the distance (motion) between them and at the same time triangulate the 3D positions of pixels[vii] matched in overlapping images. The more motion and movement around the site, the more complete the 3D model becomes. The collection of matched pixels and their calculated 3D positions become a cloud of millions of 3D points, called a point cloud. From a distance the point cloud appears as a solid model similar to 3D models seen in computer aided design (CAD) programs or video games, but as you zoom in it becomes clear it is actually a collection of millions of points. We use several different algorithms to combine these point clouds from the air, the ground and the laser scanner to create a complete scan of the site.

The resolution of SfM point clouds is much lower than a LiDAR[viii] laser scan, but SfM is much faster, easier to perform, and vastly more accurate than past archaeological methods that relied on surveyors' illustrated plans. The combination of the two technologies allows one to take advantage of both methods strong points.

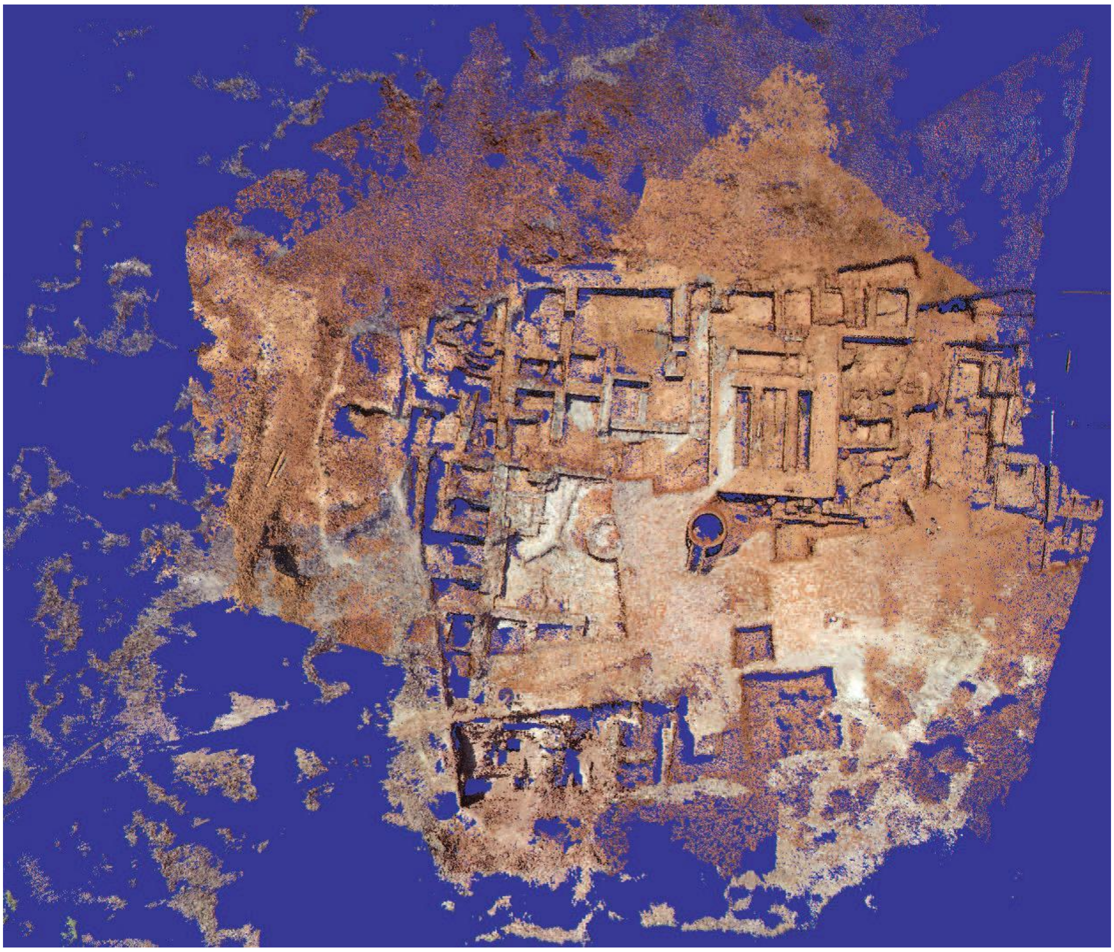

Figure 9. Final registered point cloud model of the Dedan southern excavation area combining LiDAR, terrestrial SfM, and aerial SfM. Top view; Courtesy of N. Smith (Smith et al 2014).

4.12 Gamification

The use-embodiment of various game mechanisms-characteristics, in activities-states not related to game, aiming at the solution of problems via increased users' interactivity and participation. The term "gamification" first gained widespread usage in 2010, in a more specific sense referring to incorporation of social/reward aspects of games into software (Zichermann & Linder 2013).

Due to reducing national budgets, digitization and raising expectations of visitors, new technologies can be used to improve the visitor's experience for:

- *Visualization and modeling to aid with reconstruction of old ruins and remains to enhance the visitor's experience*
- *Digitization of records to enliven and deepen the experience*
- *Re-Use and Open Access of digital records to reach wider audiences and those unable to visit in person*
- *Reconstruction used for scientific research purposes: to learn how buildings were used in different periods*
- *Transformation of content and materials through reuse and co-creation*

Gamification and games-based approaches can, in general:

- *Create an immersive experience to enhance the visitor's experience*
- *Connect up education and culture through missions and quests*
- *Open up access and transformation to more cultural collections and content*
- *Create new opportunities for scientific research...*

(Sharpe et al., 2010; de Freitas & Maharg (Eds) 2011; de Freitas, 2013; Zichermann & Linder, 2013; Papagiannakis et al., 2015).

4.13 Serious Games

Interactive simulations of cultural heritage & museum issues based in game, in which the user participates actively. That is, games with virtual worlds that have been developed especially for educational purpose, impelling users to increasingly participate, much like the games at their free time (Anderson et al, 2009; (Forte, 2010; Bell, 2008; Liritzis et al., 2015; Maturana & Varela, 1980; Reilly, 1990; O'Neil, and Perez (eds) 2006).

4.14 Drones and Balloons

Over the past year, increased interest has been developed on the hardware and software required to conduct automated aerial 3D scanning. The Unmanned Aerial Vehicles (UAVs) provide the means to capture images from the air but it is the software used to convert these 2D images into 3D models and merge them with ground scans that makes the technology revolutionary. A key component of our project is the development of a streamlined scanning system using UAVs for archaeology. (Barazzetti et al, 2010; Irschara et al., 2010). A UAV is an aerial vehicle (plane, helicopter and blimp) that does not have a human pilot on board but is controlled remotely. Disadvantage is the prevailing winds at the time and occasionally dropping of drones from failure. Wind must die down long enough to safely fly over the site.

A project of digital capture has been applied on the archaeological remains in the Dedan (modern day al-Ula) valley, Saudi Arabia. The goal of archeologists and computer scientists was to integrate 3D scanning technologies to produce 3D reconstructions of archaeological sites. Unmanned Aerial Vehicles (UAVs) serve as the vehicle which makes this scanning possible. UAVs allow the acquisition of 3D data as easily from the air as from the ground. At al-Ula, they run the LiDAR scanner, planed flight missions and fly the UAV, and took detailed terrestrial SfM capture. At the end of the day the massive datasets generated was merged within the same 3D space to create a comprehensive and accurate 3D reconstruction.

Similar combined work has been made in Mada'in Saleh, an ancient Nabatean city filled with monumental carved sandstone tomb facades, rivaled only by the capital of the Nabatean Empire: Petra. (Smith et al 2014).

These non-invasive 3D scanning techniques are applied in order to digitally preserve these sites as they are excavated, and to document the inevitable decay of carvings and structures over time, and provide objective datasets for future analysis and visualization.

5. DATA PROCESSING AND MODELING IN ARCHAEOLOGY. A CONDENSED OVERVIEW

From the digital point of view one of the first outcomes of the archaeological processualism was the use of statistical processing and quantitative methods in different domains, mathematics, geography, archaeometry, anthropology, archaeology and related disciplines. The critique of subjective methodologies pointed out the need of hyper-taxonomies for interpreting the past and thus computing archaeology seemed a tangible and sustainable way for the processualist dream: an objective "scientific" interpretation. The interaction between real ontologies, the empirical perception of material culture (objects), and their virtual ontologies (the digital representations), creates new perspectives in the domain of data processing, data analysis, data sharing, data contextualization and cultural transmission.

Last decade specialized conferences, collective volumes, proceedings, books and articles deal with such themes and on a variety of transdisciplinary and interdisciplinary topics of archaeological informatics or computational archaeology.

These literature sources include but are not limited to geographical information systems (GIS), especially when applied to spatial analyses such as view shed analysis and least-cost path analysis, statistical and mathematical modeling, scientific age calculation, classification of artifacts from qualitative or quantitative data, the application of a variety of other forms of complex and bespoke software to solve & model archaeological problems, such as human perception and movement within built environments using developed software. For example, disciplines such as computer science (e.g. advanced algorithm and software design, database design and theory), geoinformation science (spatial statistics and modeling, geographic information systems), artificial intelligence research (supervised classification, fuzzy logic), ecology (point pattern analysis), applied mathematics (graph theory, probability theory), statistics, are relevant entities to the session's essence.

Data processing & modeling in archaeology provide a looping feedback for progressive development of virtual simulation of the material culture and the scientific archaeometric methods used to decipher their internal clocks and contents (dating, characterization and provenancing, complex groupings, spatio-temporal simulation).

The ultimate purpose is educational, social, museological, cultural, touristic, sustainable and of scientific nature.

Advanced work is achieved on Fundamental research (theoretical ArchaeoInformatic science) on the structure, properties and possibilities of archaeological data, inference and knowledge building, that include modeling and managing fuzziness and uncertainty in archaeological data, scale effects, optimal sampling strategies and spatio-temporal effects, and, development of computer algorithms and software (applied ArchaeoInformatics science) that make this theoretical knowledge available to the user.

All above topics are superimposed and intersection may occur, while fundamental research topics, are included, but not limited, to:

- *advanced statistics in archaeology, spatial and temporal archaeological data analysis*
- *bayesian analysis and advanced probability models, fuzziness and uncertainty in archaeological data*
- *scale-related phenomena and scale transgressions*
- *intrasite analysis (managing data for representations of stratigraphy, artefact distributions)*
- *landscape analysis (territorial modeling, visibility analysis)*
- *optimal survey and sampling strategies*
- *process-based modeling and simulation models*
- *archaeological predictive modeling and heritage management applications*
- *supervised and unsupervised classification and typology, artificial intelligence applications*
- *modeling digital excavations*
- *archaeological software development, electronic data sharing and publishing*
- *Handling of cyber-archaeology data for related applications at epistemological, technological and methodological level through theoretical approaches and case studies*

The aim of such data analysis is to introduce the range of computational methods available to archaeologists, museologists, culturalists, scientists.

The objectives are to enable one to demonstrate knowledge and understanding of, and critically evaluate, the range of data management, process and modeling by computational methods and their contribution to archaeological research.

6. EXAMPLE OF CYBER ARCHAEOMETRY

Along these above digital cultural heritage has been enriched with a new field that of cyber archaeometry (as defined above). A first example is the petrographic microscope or polarized light microscope (PLM) which is a type of optical microscope used in petrology and optical mineralogy to identify rocks and minerals in thin sections (Fig.10-12). Archaeological materials examined include ceramics, mortars, clays, lithic tools. Minerals to identify in ceramics include quartz, feldspar, biotite, dolomite, calcite, fossils, broken tiny pieces of rock, and others within the clay fabric. The optical investigation helps in the characterization, provenance, firing temperature issues of ceramics. Petrographic microscope is virtually designed with the use of Avatar in the time-space frame of the Laboratory that navigates, explores, and controls the learning outcomes in connection to the archaeometric multisystem work (Liritzis et al., 2015). The virtual walk takes place in the virtual laboratory and follows experiential feedback of functioning the polarized optical microscope and its various mechanical parts. The identification of a mineral from cross polarized light (two nicols prisms) follows a stepwise procedure (Fig.13)

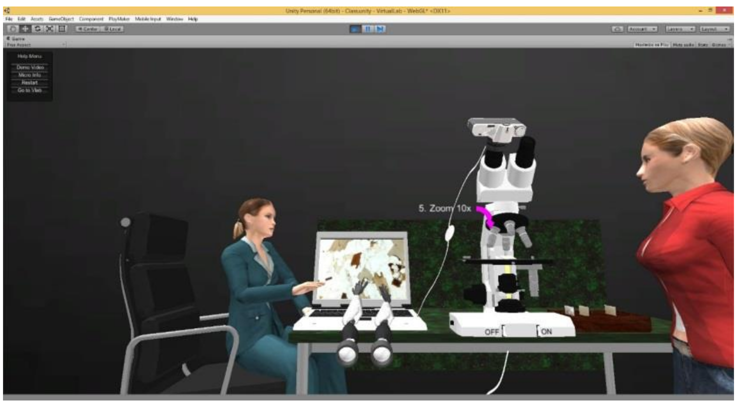

Figure 10. 3D Virtual Lab - A print screen during stepwise functioning of the Microscope.

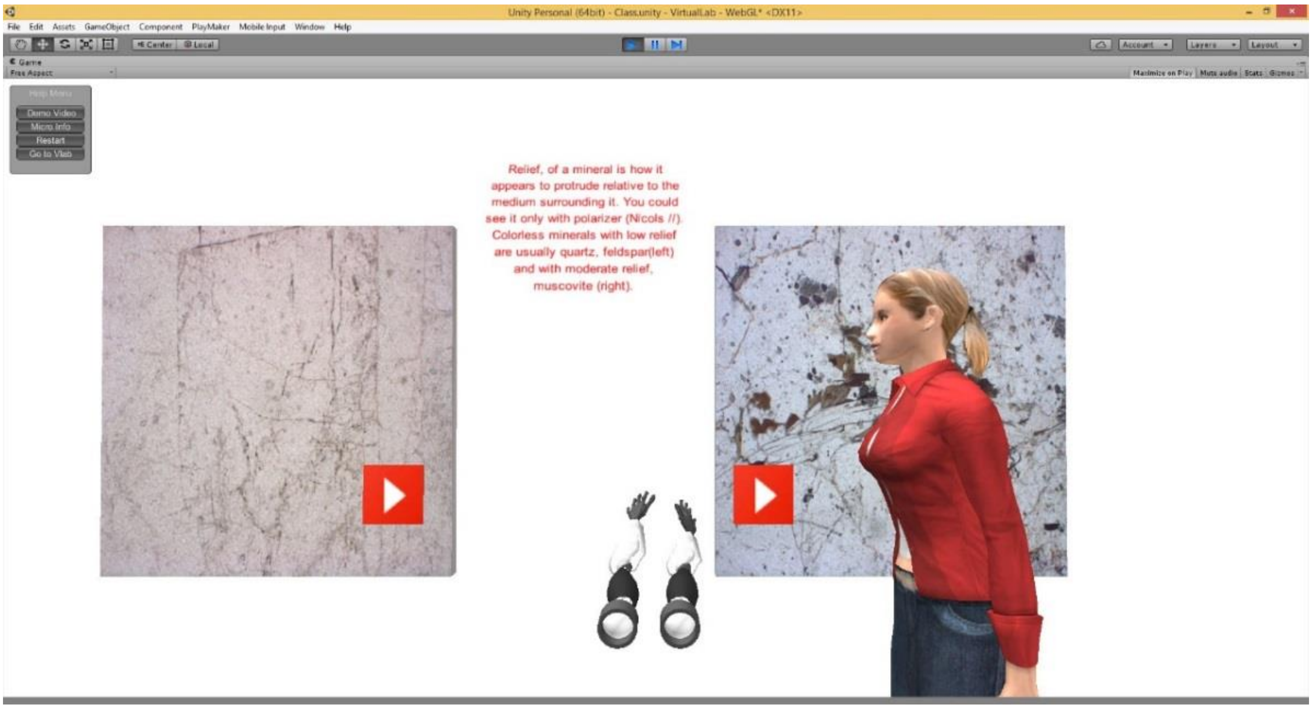

Figure 11. 3D Virtual Lab – A print screen from mineral recognition from thin section.

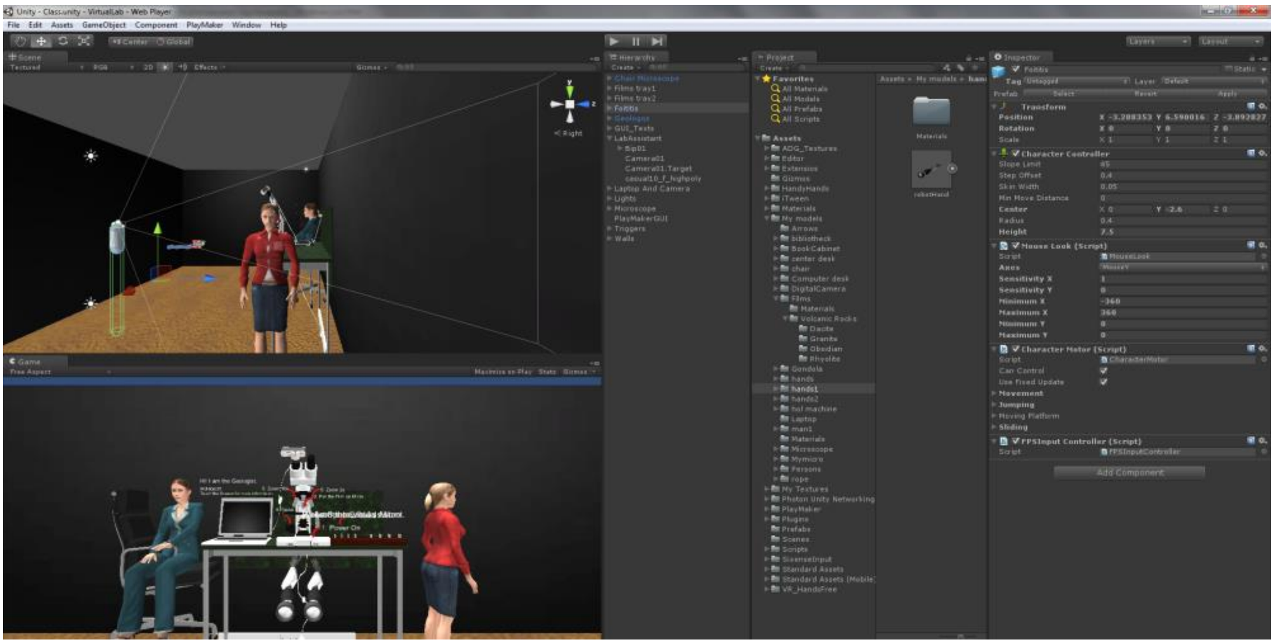

Figure 12. The development of the application is making with the 3D Modeling and Game Engine Unity3D.

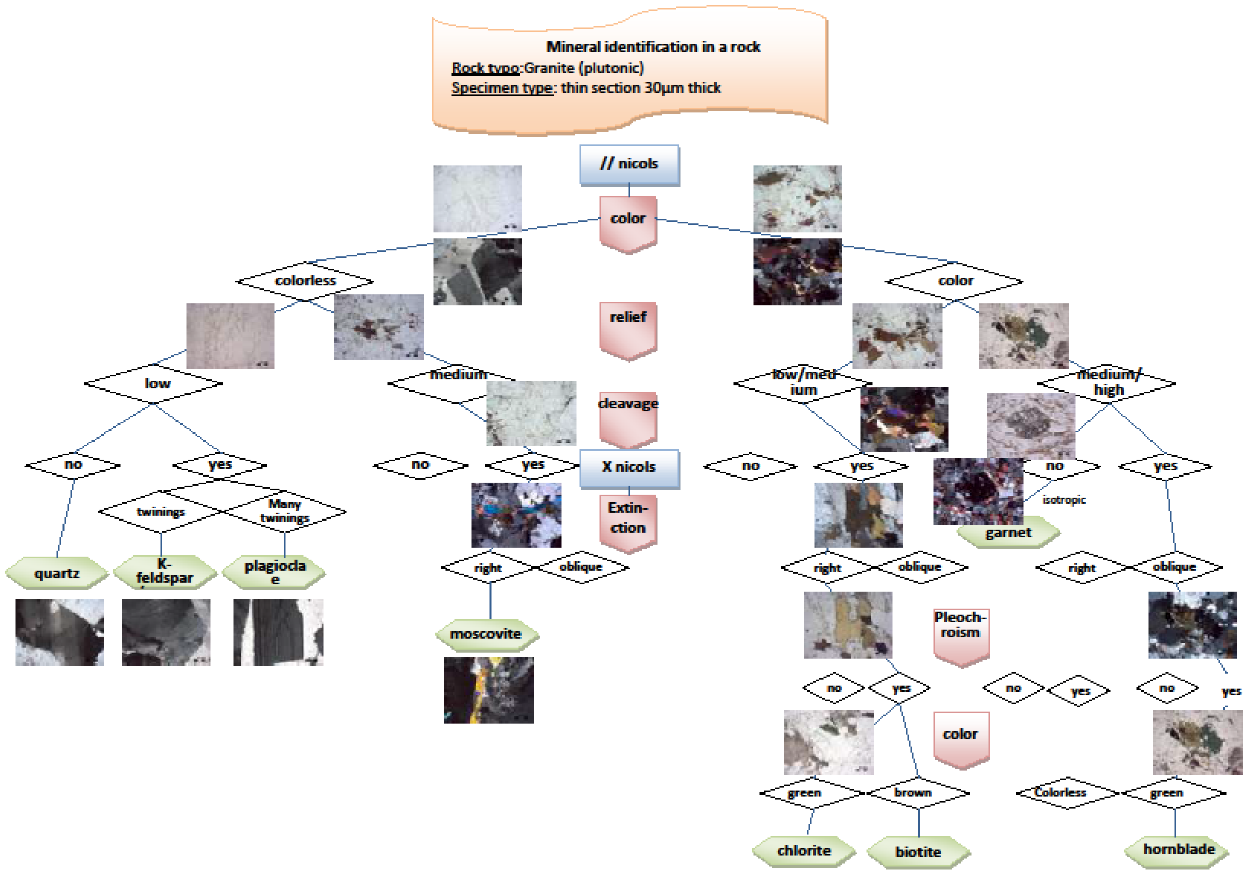

Figure 13. Mineral identification example. The stepwise procedure followed in our virtual lab.

The educational aims and anticipated results include:

- *Execution of laboratory exercises from internet via browser*
- *Making a Virtual lab for education of university students (e-Learning or from distance) without physical presence*
- *Learning in functioning of lab instruments for archaeometric work*
- *Enable students to discover knowledge through these processes, but also to interpret in their own way the laboratory results*

The benefits in the Training on a virtual microscope environment then:

- *Could take place any time without help from assistants of the lab*
- *Saves from expenses*
- *Avoids disasters and loss of material*
- *It can be repeated many times*
- *Partial steps can be repeated, giving students the opportunity to analyze the process from different perspectives and opinions*

At the end, the learning outcome for the Optical Microscope inheres:

- *Identification of content of thin sections (minerals, organic matter, scrap fragments, mineralogical structures etc)*
- *Wide spectrum of archaeo-materials*
- *Trial & error*
- *Satisfies Target, has analytical reflection*
- *Functioning of equipment*
- *Familiarization*
- *Synergy, teamwork, understanding*

7. CONCLUSION

The 3rd Cultural (digital) Revolution is currently recognized with the cyber-era which develops for an environmentally sustainable abundance. The ulterior over is the point in space-time in which coalition of science, technology and art is openly combined. A motto, for the current new advanced digital and globalization era in cultural heritage, could be "*cyber-heritage is linking arts and cultures and intercultural understanding*". The dynamic 3D screens and digitally processed fragmented cultural heritage combined to relevant scanning or photographic technologies create a virtual environment as a real. Museums, and archaeological/ historical parks, monuments and in situ works of art are most potential targets for the online museums. However, questioning the electronic processing and presentation of museum artifact collections and monuments with the application of new technologies and in internet facilities has initiated to discussions on the appropriateness of such presentations. At any rate virtual reality offers a unique tool to people to study the past and get an "immersive" feeling.

Modern approach is to follow current computational theories of perceived image of the object and improve the way archeology deals with interpretation of human behavior in the past from the analysis of visual and non-visual data.

Today digital cultural heritage has been enriched with new fields originate in natural sciences and most recent advancements of optical techniques in marine, terrestrial space sciences. Cyber archaeology and cyber archaeometry and other terms create a hyper cultural heritage unparalleled ontology.

Cultural heritage is modeled and huge data accumulate that reinforces novel processing machines (software and hardware) to enter the field of data management.

The need for objective methodologies point out the need of hyper-taxonomies for interpreting the past leading computing archaeology to an objective "scientific" interpretation.

The evolution of technology from analog, mechanical, electronic, may lead to new revolutionary hybrid forms, involving the still revealing technology of light. Multimedia technologies involves serious thinking when it is associated with objectiveness and social awareness.

The virtual archaeology examples over all the World, as a result of advanced technology emerging from computer sciences, however, stress the naturalistic methodology, challenges and improves digital reconstructions and serious games and at the end offers a holistic approach, taking into account also the value of remote sensing learning outcome and research efficiency. After all, natural and digital methods combined offer interpretations that is the basis of a synoptic and synthetic philosophy of humans that combines art and science corresponding to classical *techne, logos* and *ethos.*

ACKNOWLEDGEMENT

The authors Ioannis Liritzis and Fahad Mutlaq Al-Otaibi extend their appreciation to the Deanship of Scientific Research at King Saud University for funding the work through the research group project No. RGP-VPP-194. We thank Dr Ioannis Iliopoulos (Patras Univ., Greece) for his help in thin sections flowchart.

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FOOTNOTES

[i] Berners-Lee's vision of a global hyperlinked information system became a possibility by the second half of the 1980s. By 1985 the global Internet began to penetrate Europe and the Domain Name System (which the Uniform Resource Locator is built upon) came into being. In 1988 the first direct IP connection between Europe and North America was made and Berners-Lee began to openly discuss the possibility of a web-like system at CERN (Berners-Lee, et al, 2004)

[ii] The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

[iii] People who practice a hunting and gathering subsistence strategy simply rely on whatever food is available in their local habitat, for the most part collecting various plant foods, hunting wild game, and fishing (where the environment permits). They collect but they do not produce any food. For example, crops are not cultivated and animals are not kept for meat or milk. Hunters and gathers do and did modify the landscape to increase the amount of available food. Food Production: General term which covers types of domestication involving both plants and animals, each of which requires radically different practices. Cultivation: Term refers to all types of plant culture, from slash-and-burn to growing crop trees.

[iv] Archaeometry: the application of methods and techniques from the natural sciences to culture materials for solving archaeological problems related to dating, characterization and provenance, ancient diet, ancient technology, astronomy on culture.

[v] In Figure 7 the screenshot is being presented from the educational and cultural gaming experience offered by the game "The Great Walk" that takes place on the Filopappou Hill just opposite to the Acropolis in Athens, Greece. In this game, the player (a kid in Athens, who just walked up by a nightmare -- of seeing Athens being destroyed) try to free Kekropas, the mythological founder of Athens, who has been captured by the 9 muses (villains in this case) and chained in a cave. If Kekropas is not freed before the dawn of the next day then the known history will be rewritten and Athens will cease to exist. The player faces various enemies throughout his/her course towards the cave that Kekropas is being held, enemies from various eras of Athens. To defeat these "guards" and get the clues (represented as stars in the game) needed to proceed, the player should either face the guards by using various power-ups (various luminous objects in the game) or by trying a stealthy approach. The game finishes when the player defeats the villain muses and frees Kekropas.

[vi] Algorithm: is a self-contained step-by-step set of (mathematical) operations to be performed. Algorithms exist that perform calculations, data processing and modeling and automated reasoning.

[vii] In digital imaging, a pixel, pel, or picture element is a physical point in a raster image, or the smallest addressable element in an all points addressable display device; so it is the smallest controllable element of a picture represented on the screen.

[viii] Remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.