Digitization of Archaeological Remains: The Pathway of future Archaeological Research.

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A. Introduction

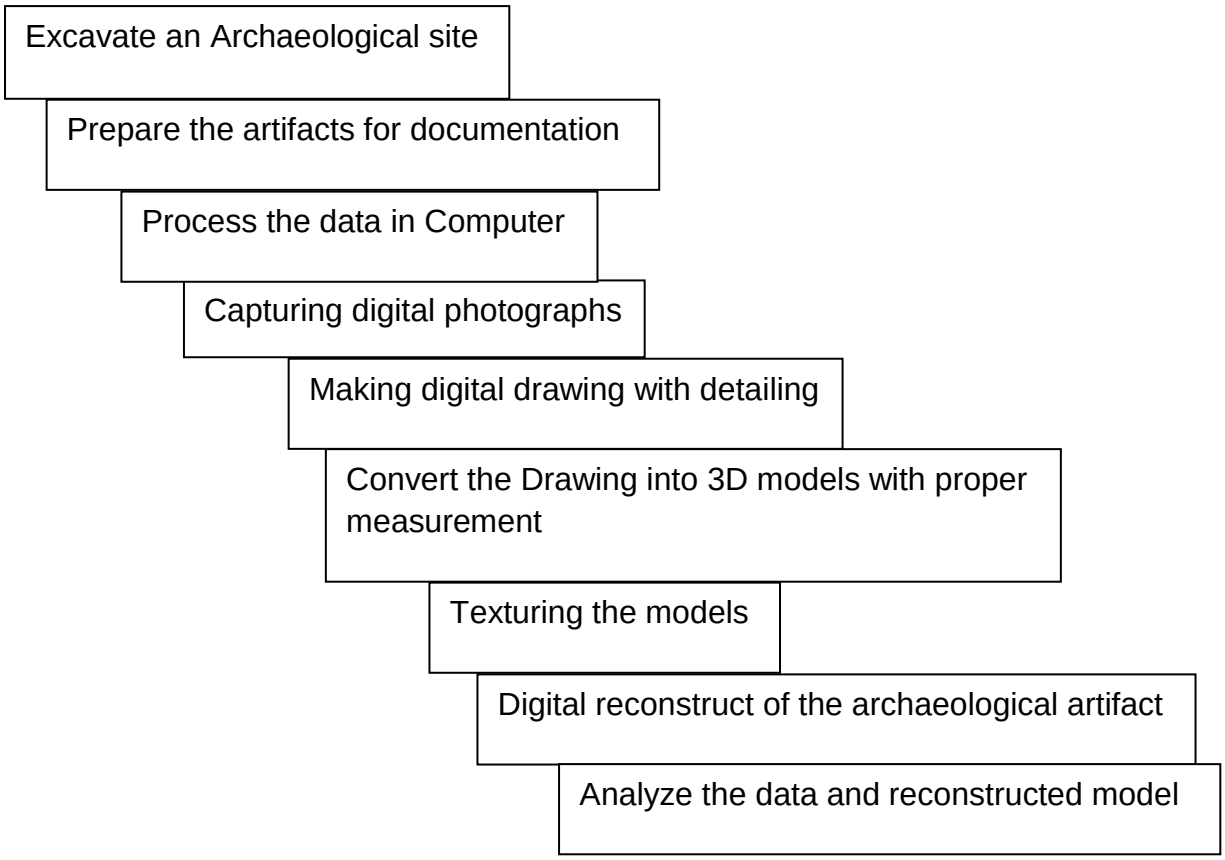
‘‘Excavation is destruction’’ that emphatic exhortation for careful archaeological recording. Archaeology has a specific role as a science, because materiality in the form of collections and different kind of documents has had a major role in it. Digitization has changed archaeology deeply. Archaeology can be seen as someone sitting at a desk analyzing data on a computer. More time is put into digitizing history. Specifically archaeology is the study of the past through the systematic recovery and analysis of material remains. The digitalization of data requires its expertise consequently challenge of the archaeologists in the field. The transformation of archaeological data into a digital format has been defined as de-materialization. The process of digitalization in archaeological excavation and exploration and documentation helps to archives as translation of older materials into digital format.

Archaeological studies today employ three-dimensional models of findings and of sites in several study and communication phases descriptive classification, morpho-typological comparative analyses, conservation, hypothetical reconstructions, scientific Popularization, virtual museums, etc., and therefore is highly required to find adequate systems at a reasonable cost to generate digital models of series of findings as per standard procedures.

When you think of archaeology, the typical image of someone with a tacky hat and khaki pants digging in the dirt comes to mind. Nowadays Archaeology can be seen as someone sitting at a desk analyzing data on a computer. More time is put into digitizing history. This means that archaeologists rebuild forgotten history by going out and finding places where history has been literally buried and reconstructing the past so we can define our cultural heritage. The aim of our task is to visualize the archaeological remains through a modern technique; you can see a digital model of the site. Three-dimensional software has greatly improved the ability to see or visualize a site. In order to reconstruct the past the work is dedicate to recreate some artifacts from a recent excavated site. In particulate artifacts a Chariot and a Coffin is taken as a reconstructed project. As a final output of this particular task, is to give an impact to modern learner to understand the remains in an upgrade and detailed version.

The digital 3D acquisition of objects and structures is generally performed by means of (i) passive techniques (image-based methods) such as photogrammetry, (ii) active sensors (range-based methods) such as laser scanner, (iii) integration of active and passive techniques. The best and most appropriate technique depends on the object to be surveyed or the area to be examined, on the user experience, on the budget, on the time available and on the goals of the research. A simple consumer grade digital camera, calibrated using ad-hoc algorithms and procedures in the lab, can be used for the surveying and successive 3D modelling. On the other hand, active sensors, such as laser scanners, collect directly metric 3D point clouds of artefacts or sites that can afterwards be used to produce highly accurate and detailed 3D models. The use of laser scanners in the archaeological sites, however, is unusual because of the high costs of instruments. 3D models and 2D products are produced and presented critically comparing the employed software and instruments, reporting possible guidelines too. In this paper, I present a research that defines some different 3D surveying techniques and some other digitization methods and its process and affect the output for archaeological documentation needs.

B. Work flow



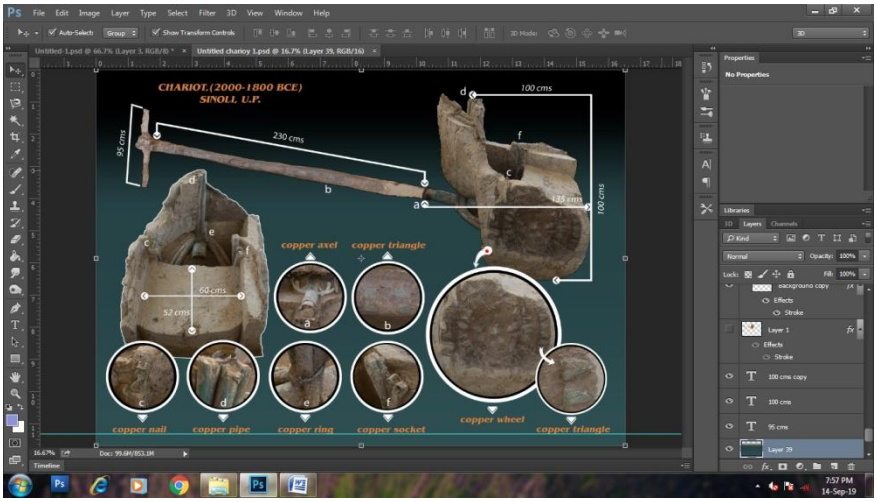
C. Software details for reconstructing artifacts.

Software:-

Names of software	**Purpose for using**
Adobe Photoshop	For drawing, 2D Image and Photographs composition
Corel draw	For Graphics processing
Macromedia Flash	For 2D Model making
Blender	For 3D Model making by actual photographs
Mesh lab	For 3D Modeling and creating mesh
Autodesk Maya	For 3D Modeling, Texturing and Conjectural reconstruction of artifacts
AutoCAD	For 2D Graphics and Modeling
Adobe Premier Pro	For Video Editing
EDIUS	For Video editing

Software Description:

Adobe Photoshop interface



Adobe Photoshop

When Photoshop was first introduced back in 1990 it causes quite a stir amongst the creative community. For the first time, designers and photographers were able to perform image editing tasks without restoring to high end equipment that cost double the amount. It started a revolution that continues to this day. Over the years there have been many other programs that perform similar works and functions like Photoshop but the Adobe Photoshop is outstanding. Adobe Photoshop is a massive program and it would take a volume of work to cover every parameter of every function in a detailed way. While using the Adobe Photoshop one will quickly come to realize that there is often multiple way of accomplishing the same task.

Photoshop is the software that is extensively used for raster image editing, graphic design and digital art. It makes use of layering to allow for depth and flexibility in the design and editing process, as well as provide powerful editing tools, that when combined, are capable of just about anything.

There in the field of archaeology the software is used as a medium of hand drawing to digital drawing. In this graphic software the photographs and the scan drawing is been modified into digital form and made a perfect reference for further 3D modeling. Its representation of photographs along with measurements helps any learned person for any kind of further research.

Corel Draw

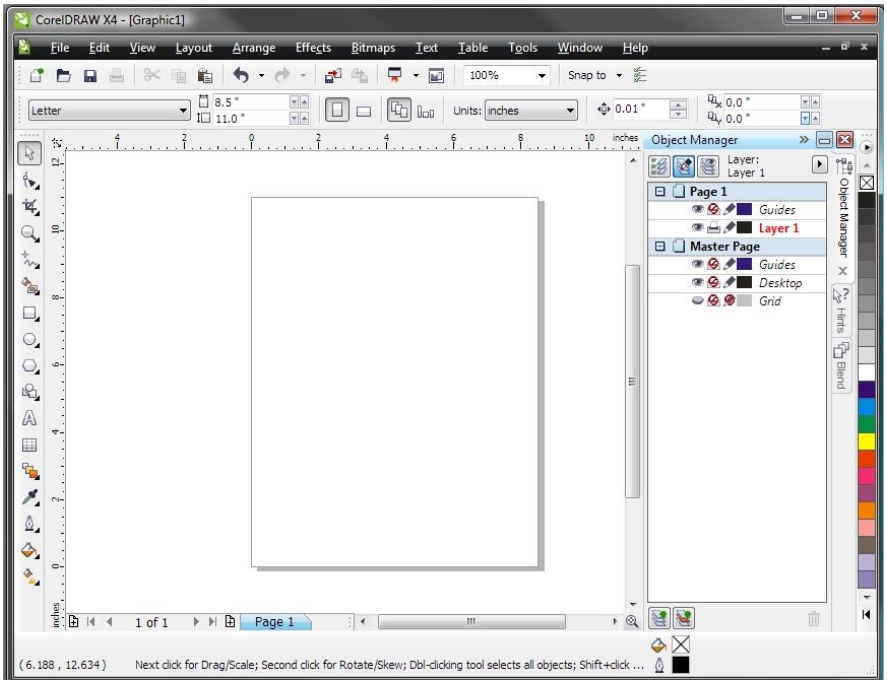
CorelDraw is one of the most popular and powerful graphics programs and gives designers a most rewarding and enjoyable work experience. It is built and designed to meet the day-to-day demands of working designers. CorelDraw software is available in the market and once loaded onto the computer, you can get started with your designing work. Some of the major advantages are, we can save a lot of time and labor. We can make designs with very great accuracy. We can make a number of color combinations of one design in a very short-time period. We can make very complicated designs with different texture and color effect very easily.

Achieve outstanding results with Corel an affordable collection of powerful 2D drafting and 3D design tools, purpose-built for architecture, engineering, construction (AEC) and manufacturing professionals who demand precision and turn visualization into a realization. DWG file support for efficient collaboration and STL support for productive 3D publishing and printing. In the modern case of

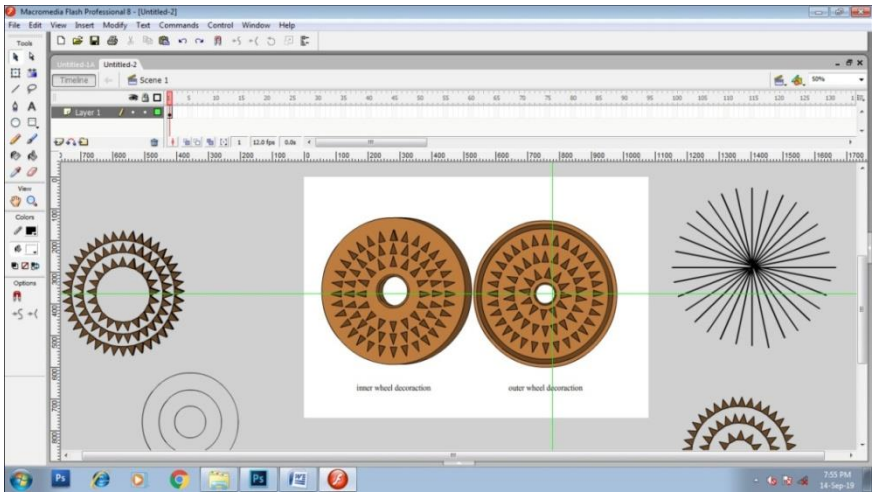
archaeology the 3D printing is gives us a new wing to development our skills and visualization of any missing parts of artifacts into a real dimension.

Unleash Corel CAD, a powerful collection of design tools developed expressly for manufacturing, construction, and engineering professionals. Conceptualize, plan, draft, layout, and edit with the assistance of a leading CAD software. With an expansive feature set, your 2D drawings will come together expertly.

Corel DRAW interface



Macromedia Flash



Adobe Flash is a multimedia software platform used for production of animations, rich web applications, desktop applications, mobile apps, mobile games, and embedded web browser video players. Flash displays text, vector graphics, and raster graphics to provide animations, video games, and applications. It allows streaming of audio and video, and can capture mouse, keyboard, microphone, and camera input.

Macromedia Flash is a tool that allows powerful animations, and 2D graphics design and models are for interactive features and other complex elements to be embedded in Web pages and for other purpose.

In this field of digital archaeology it is used as a 2D model making, drawing and many more graphics and texturing purpose with more impactful and detailed output with acute measurements. Basically one can easily make any hand drawing to an impactful digital drawing with a colorful presentation. The simple tools is so easy and user friendly to make any of your dull presentation into a most professional output.

Blender

Blender is the free and open source 3D creation suite. It supports the entirety of the 3D pipeline—modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing and game creation. Advanced users employ Blender's API for Python scripting to customize the application and write specialized tools; often these are included in Blender's future releases. Blender is well suited to individuals and small studios that benefit from its unified pipeline and responsive development process. Examples from many Blender-based projects are available in the showcase.

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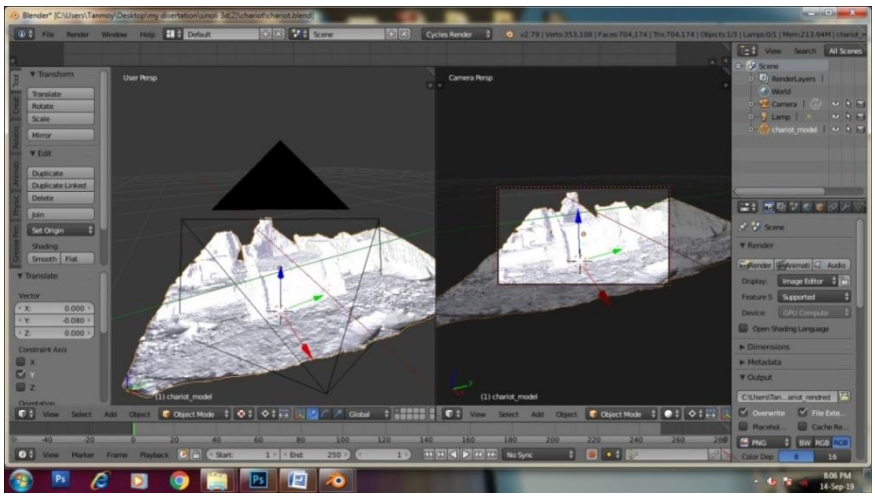
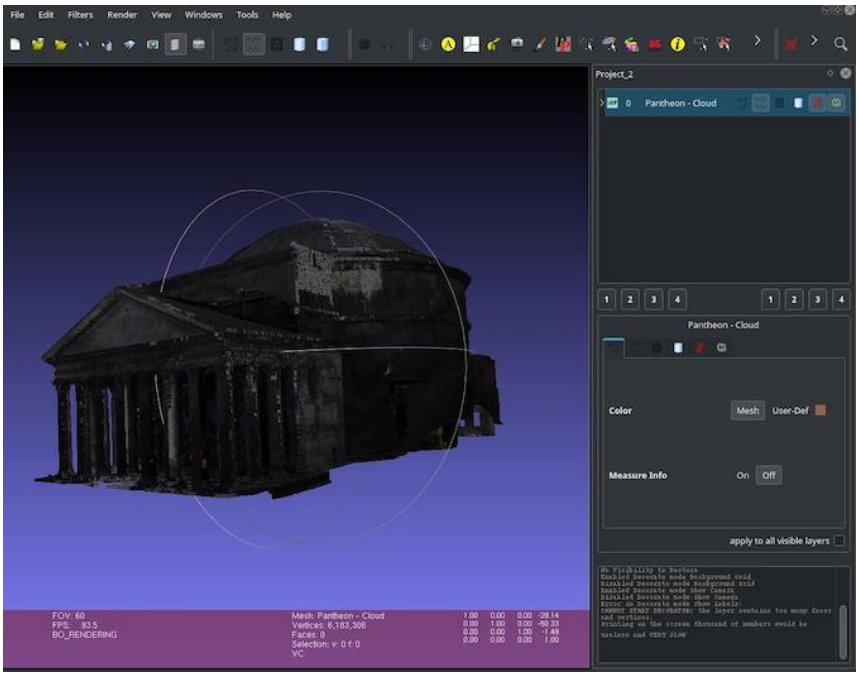
Blender interface



Mesh Lab

Mesh Lab is a 3D mesh processing software system that is oriented to the management and processing of unstructured large meshes and provides a set of tools for editing, cleaning, healing, inspecting, rendering, and converting these kinds of meshes. It is well known in the more technical fields of 3D development and data handling. The automatic mesh cleaning filters includes removal of duplicated, unreferenced vertices, non-manifold edges, vertices, and null faces. Remaining tools support high quality simplification based on quadric error measure, various kinds of subdivision surfaces, and two surface reconstruction algorithms from point clouds based on the ball-pivoting technique and on the Poisson surface reconstruction approach. For the removal of noise, usually present in acquired surfaces, Mesh Lab supports various kinds of smoothing filters and tools for curvature analysis and visualization.

The 3D data alignment phase is a fundamental step in the pipeline for processing 3D scanned data. Mesh Lab provides a powerful tool for moving the different meshes into a common reference system, able to manage large set of range-maps. The visualization features of Mesh Lab can help in graphically present the peculiar characteristics of a 3D model. It is possible to control the camera perspective/orthographic view parameters, and use predefined canonical views. Mesh Lab also offers a high-resolution screenshot feature, extremely useful in creating a graphical documentation of a survey.

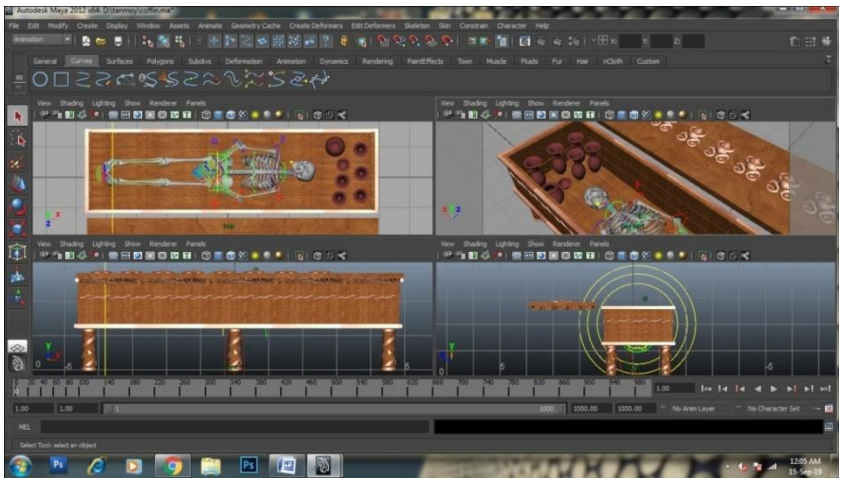


Autodesk Maya

Maya is 3D computer animation, modeling, simulation and rendering software. Maya incorporates the natural laws of physics to control the behavior of virtual objects in computer animation. Maya can produce videos and modeling of any item or character that are more life-like than has been possible with less sophisticated programs. Autodesk Maya has won several awards for professionalism and power. Not to mention, it is one of the leading packages for the 3D animation industry mainly because it provides a huge amount of objects and effects to choose from.

In this case of digitization the archaeological remains and an artifact, Maya plays a major role for visualizing and executes the models in more realistic way. From the drawing and acute measurement and detailed documentation its gives a perfect output of any antiquity and artifacts. Using some tools of drawing in polygon and curves and some general lighting items it's accomplished the final model. If your projects tends to involve large data sets you'll enjoy Maya's ability to handle complex geometry with relative ease due to the many technical innovations that have been engineered into the core software. At the end the software basically need your drawing skills and observation as well as patience too.

Autodesk Maya interface

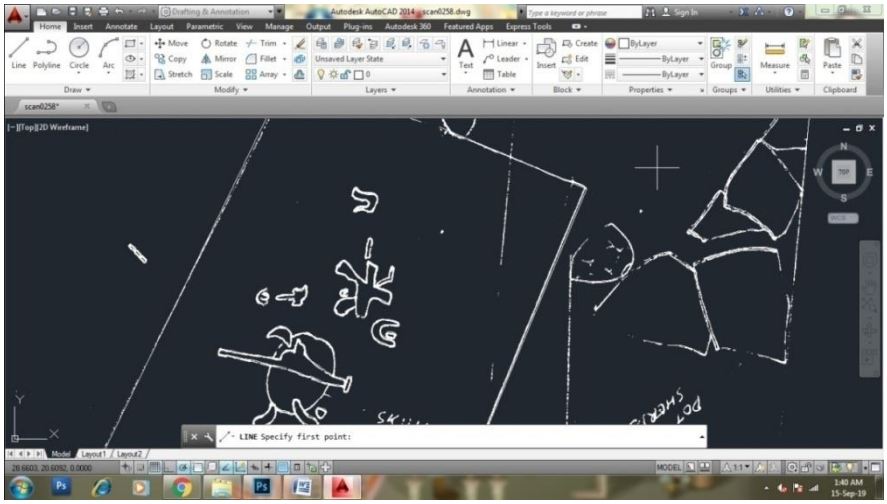


AutoCAD

CAD stands for 'computer-aided design' -- Autodesk created the most popular program. AutoCAD is a computer-aided tool that allows many different types of designers to create diverse kinds of drawings and designs. This program helps designers create their designs much more quickly than by hand and offers many quick, easy, and useful features, such as copy and paste. AutoCAD can create any 2D drawing and 3D model or construction that can be drawn by hand. The program also allows the user to group or layer objects, keep objects in a database for future use, and manipulate properties of objects, such as size, shape, and location. AutoCAD and its lighter, more streamlined version, AutoCAD LT, are both leading design and engineering software programs. Both offer 2D drafting and documentation along with dozens of design, connectivity and customization features. The primary difference between the two versions is that AutoCAD capabilities include 3D modeling and collaboration tools, along with several other special features.

In this digitization project its acts as a 2D line drawing tracing and making of 2D drawings. By this the hand drawing plan of the excavated site is trace down and makes it in a digital format. Using this software is a very easy task to omit the mistakes done by hand drawing and as a final product getting a fresh and accurate image.

Auto CAD interface

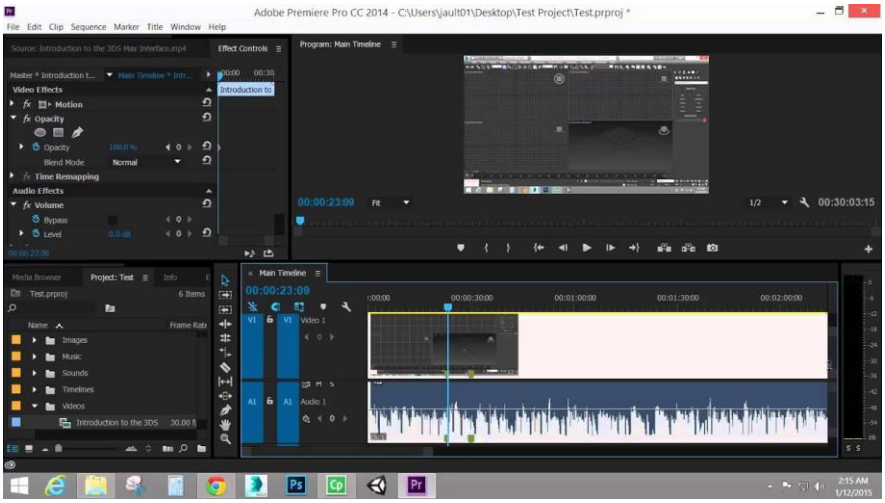


Adobe Premier Pro

Adobe Premiere Pro is a widely used software applications for video editing on Mac OS or Windows computers. Premiere Pro is used for editing videos, commercials and other film, television, and online video. It is a comprehensive video editing software application and is also available as part of the Adobe Creative Cloud set of applications. Premiere Pro is often used in conjunction with After Effects and Photoshop on creative projects.

Premiere Pro can be used for all common video editing tasks necessary for producing broadcast quality, high-definition video. It can be used to import video, audio and graphics, and is used to create new, edited versions of video which can be exported to the medium and format necessary for distribution. When creating videos using Premiere Pro, various video and still images can be edited together. Titles can be added to videos, and filters can be applied along with other effects.

Adobe Premier Pro interface



D. Modern technology and it's uses and Outcomes.

As we know Archaeology is a multi disciplinary subject, for this archaeology has to contests with the modern techniques. In the modern world we have to develop ourselves as per the modern science and technology. In the old traditional methods for any data interpretation and evaluating any excavated sites we have to spent lot of time and patience. We don't have and singe and particular lab for processing any scientific data collected from any site. In terms of scientific approach we have to depend on others. As we know in case of interpretation the scientific data gives us a new perspective and micro level. From using such data we can examine and make a perfect report of any sites. Where else we can also make a perfect assumption without excavate or destructed any site. Using some other modern techniques and machinery we can now also process our findings and data in a very short time and with more reliable and accurate way in terms of further possibilities.

Some modern techniques and machinery used in Archaeology

In application of modern techniques and machinery we can use such variety and mechanisms in our archaeological field.

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Name of technique	**Machinery used**	**Purpose for using**
Matrix - Geo	Drone	Survey with different parameters
Photogrammetry	Drone	Survey and reconstruction of surface in 3D
Magnetic surveying	Magnetometer	Survey for tracing
GPR	Drone	Survey
Laser scanning	Scanner	Scanning and Reconstruction
Metal detection	Metal detector	Detecting of metals
LIDAR and Digital Terrain Modeling	Drone	Survey and reconstruction of surface in 3D
Drone photography	Drone	Overview photography (ground plan)
Microscopic analysis	Microscope	Detailed scientific study
X-Ray	X-ray machine	Detailed study in different scientific aspect
XRF and XRD	Portable X-ray machine	Detailed study in composition analysis
Holograms	Laser Scanner	Virtual image projection
3D printing	3D printer	Making an actual copy of any artifacts

Processing of techniques

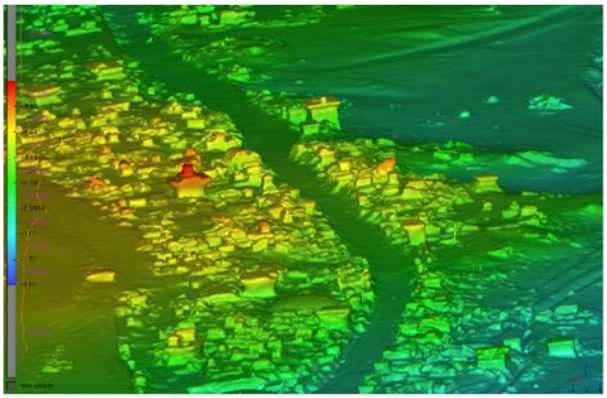
Matrix – Geo

Matrix Geo uses world class technologies and best practices to help Archaeologists in Restoration. Reconstruction and Documentation by using modern technologies is really efficient to collect accurate information and perform the analysis to help in taking quick and reliable decision making. Matrix-Geo is specialized in conducting aerial survey through well-equipped drones and drone LiDAR for indoor and outdoor survey of an Archaeological site for precise documentation of structures and other items found during excavation.

Photogrammetry

Unmanned aerial vehicle (UAV) photogrammetry has shown a very rapid development in many fields, especially in archaeological excavation areas and architectural complexes, where it offers a detailed generation of three-dimensional (3D) data and their updating during time, and where it proves to be a very flexible tool applicable in many types of compound areas with different formal features. The use of aerial acquisition provides nowadays highly effective results, in fact, today in the field of archaeological research. In order to obtain a correct UAV survey, the metric approach that needs to be followed concerns the data acquisition: the images, the coordinates, and the altitude of the camera centre. These can be calculated either through a traditional photogrammetric approach, using terrestrial topographic ground control points (GCPs) or by means of direct camera Geo-referencing (using the measures derived from the on-board sensors GNSS and IMU).

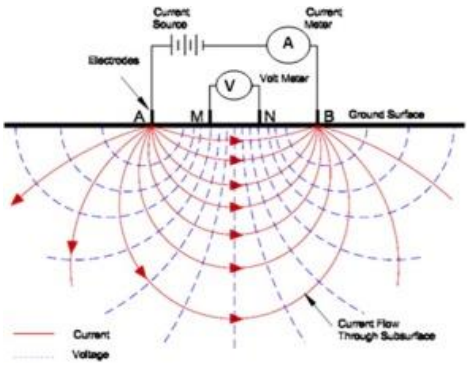
Contour map of site



3D elevated map

Magnetic surveying

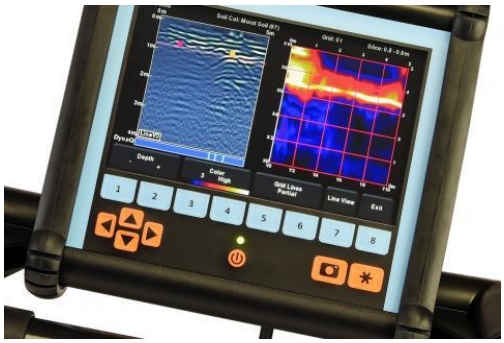
Magnetic fields exist around us. We cannot see or feel them, but we can measure them with sensitive instruments called magnetometers. As earth magnetic survey, can be an effective geophysical technique suitable for the definition of archaeological features such as former structures and in filled ditches and pits. Resistivity or Magnetic survey can be particularly useful for locating structural remains associated with building footings. Surveys are possible over grass, crops and open soil although the results can vary considerably due to weather conditions and other factors that influence ground moisture levels. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response and the moisture retentive content of a ditch can give a low resistance response.



Magnetometer surveying at site

GPR

Ground penetrating radar survey can prove effective at locating archaeological features underneath a wide range of surfaces that cannot be surveyed by any other geophysical technique. Good results can be obtained underneath concrete, stone, tarmac and through grass and soil. In addition, an indication of depth can be provided which may prove highly useful where intrusive work is required. Archaeological Surveys carry out the majority of work using the UTSI Ground survey system with either 400MHz or 250MHz antennas.



GPR machine display

GPR survey records reflected radio waves that are pulsed into the ground as the radar antenna is dragged along the ground surface. Changes in the ground make-up, such as from soil to stone, provide conditions where some of the transmitted energy is returned to the surface. In this way, subsurface features can be mapped. Careful timing of the returned radio waves along with calculations of the ground's dielectric constant can allow an estimate of depth to be made. The transmitted radio energy is very wide in bandwidth but peaks at the resonant frequency of the antenna. As resolution is a function of the transmitted wavelength, a 400MHz system will have a higher resolution than a 250MHz system; however, the lower frequency system may have superior penetration which may be critical in certain conditions. 250 and 400MHz systems are typical of those used for archaeological prospection.

GPR surveying machine

Laser Scanning

The use of laser scanning for archaeological applications has escalated in present days and this relatively new technology is altering how archaeologists are approaching the past's material record. At the most fundamental level LS provides extraordinarily precise three-dimensional (3D) digital surface models of moveable artifacts, buildings, site terrains, and even entire landscapes. Fully Geo-referenced 3D data integrates with CAD and GIS applications, meaning the products of laser scanning surveys work alongside traditional mapping or survey data, providing a rich and detailed record. Scanned models are valuable

tools for documentation and analysis, but also provide a unique way to present archaeology to the public, through websites and interactive digital applications.

The portable laser scanning machine is specially designed for outdoor applications due to its small size, extra light weight and extended scanning range. The scanning results even in challenging environments, narrow job-sites, dusty or humid areas, in rain or direct sunlight applications. An on-site compensation tool allows data quality optimization on-site. Integrated GPS & GLONASS receiver enable easy
positioning. HDR imaging and HD photo resolution ensure true-to-detail scan results with high data quality.

Laser surveying machine

Metal detection

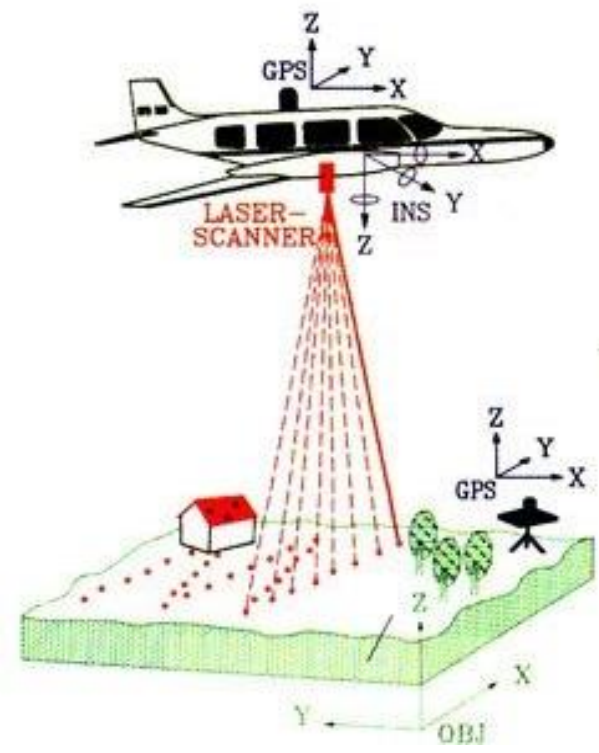
Metal detectors are inexpensive and effective remote sensing devices that should become part of the basic tool kit of archaeologists working at sites where metal artifacts are likely to be a part of the site assemblage. Metal detectors find metal objects just as shovel tests or test units might be used to discover a site's content, depth, or boundary. In archaeological applications the metal detector inventory process, coupled with precise and accurate recording techniques to be described, is very similar to the well-accepted routine shovel test field survey technique. Today, the use of non-destructive and non-intrusive methods of archaeological investigation is ingrained in the discipline, and archaeologists have turned increasingly to methods of remote sensing for initial site investigation. Examples of investigations employing metal detectors as archaeological tools demonstrate the investigation of virtually any archaeological site containing metal artifacts can benefit from the use of metal detectors. Metal detectors can be used to identify sites even when no surface evidence exists. They can help determine site boundaries by establishing the extent of metallic debris associated with an occupation.

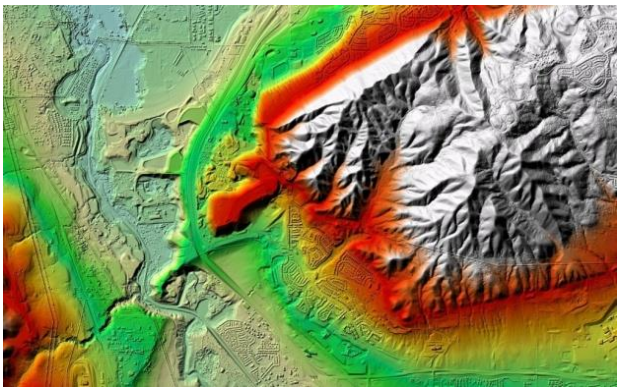

Metal detector

LIDAR and Digital Terrain Modeling

LIDAR (light detection and ranging) is a technology that's gained lot of traction in archaeology over the last decade, though it's been one of the more costly tools in the kit for archaeologists lucky enough to use it. Because of this, most archaeologists tend to look for LIDAR data from large scale mapping projects funded by state and federal budgets. In these types of projects, the LIDAR sensor is flown in a grid pattern by an aircraft over large regions and the results are resolutions of around 1-5 meters, though some there are better resolutions

in some projects. The LIDAR sensor is payload with a GPS and data collector. The way LIDAR works, in a nutshell, is by shooting millions of laser beams to the ground. The wavelength of the beam changes because of the distance of the return, and creates a point. Archaeologists are interested in "last returns" since this is the ground level, since it can capture tops of tree canopies, undergrowth, and so on. Using UAV mounted LIDAR for much in the same way they're using GPR and electrical resistivity today. It makes sense to use these kinds of techniques in order to avoid unnecessary digging or even digging at all since archaeology is necessarily a destructive process. At the very least, this is one more tool that can give the archaeologist information on where to focus an excavation rather than trying to guess by putting in test pits.





3D map with elevation

Drone photography

Uninhabited Aerial Vehicles (UAVs) are changing the way that archaeologists conduct fieldwork. Unmanned Aerial Vehicles (UAVs) or drones are used as a platform to produce accurate topographic maps with a considerable reduction in time and costs associated with fieldwork when compared with a total station. Birds' eye views of archaeological sites and landscapes provide excellent vantage points for our understanding

DGI Phantom Drone

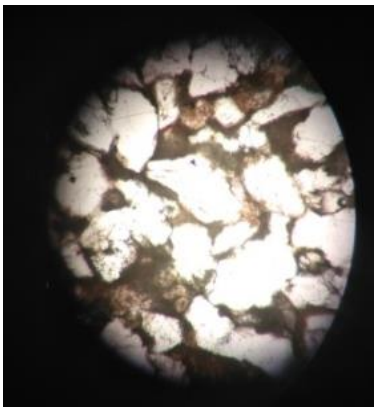
of the past. Images from archives, balloons, drones, kites, poles, and satellites are changing the ways in which we carry out archaeological investigations. There has been a significant increase in the use of UAVs throughout the world to aid in archaeological investigations. The

ability to acquire images that encompasses large and small areas is its main and most frequently used attribute. The newest way to use UAVs in archaeology is for mapping and 3D

photogrammetry. Using images of maps and sites of interest it is possible through computer technology to produce a very accurate 3D model. Instead of personally visiting a site you are able to view it on your computer.

Microscopic analysis

Scanning electron microscopy or the microscopic analysis (SEM; this acronym is used for both the instrument itself and the technique) has been broadly used in archaeology. The SEM is capable of two basic functions: imaging and providing compositional information. Consequently, it has been utilized for nearly every archaeological application in which one wishes to examine magnified images of a specimen and determine its composition on a microscopic scale. All SEMs permit one to acquire highly magnified images of a specimen. The range of magnifications possible is much greater with SEM than with visible-light microscopy (VLM). Depending on the instrument, the magnification can be adjusted as low as 5X (equivalent to a hand lens) and as high as 200,000X (roughly 100 times better than a powerful VLM) or more. In the science branch of archaeology the microscopic analysis evaluate the measurements of the physical and chemical prosperities of archaeological materials.

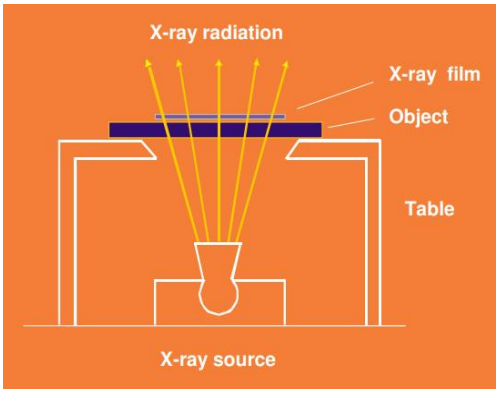


Microscopic view of a stone

Polarized microscope

X-Ray

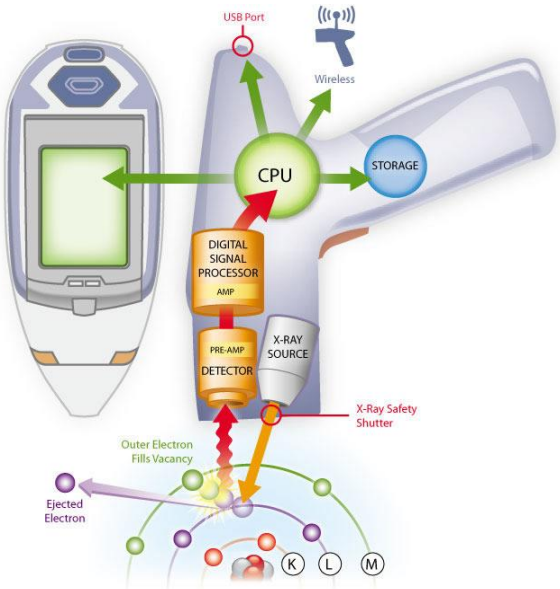
The application of X-rays to archaeological objects with the goal of gaining insight into both their construction and chemical composition, in a non-destructive manner, dates back to the discovery of radiation. Nowadays, X-ray techniques, such as X-ray fluorescence and diffraction are standard tools. The application of analytical techniques, initially developed in the field of materials science, for objects of art and archaeology gives the art



historians and archaeologists the possibility to gain information about the material composition of such objects and prepares answers to the questions of where, when or by whom such an artifact was made. Additionally, such investigations can help to understand the way of manufacturing artifacts and hence the way of life of the cultures studied. Scientific investigations are also valuable and in some cases indispensable for conservation projects in order to differentiate the original parts of an object from later additions, former restoration works, falsifications or even fakes.

XRF and XRD

X-ray Fluorescence (XRF) technology for providing immediate, actionable data for artifacts in archaeology. XRF a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) x-ray emitted from a sample when it is excited by a primary x-ray source. Because this fluorescence is unique to the elemental composition of the sample, XRF is an excellent technology for qualitative and quantitative analysis of the material composition.



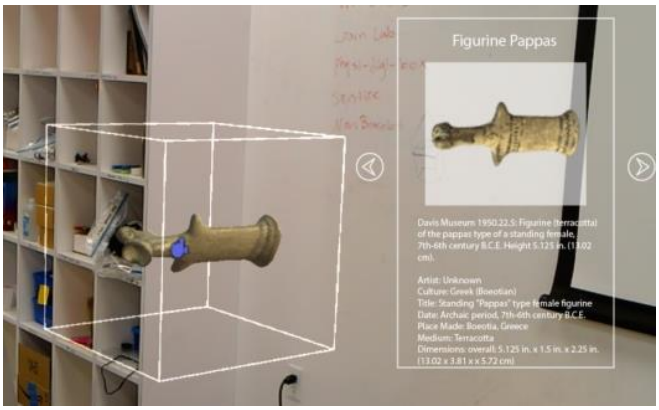
A solid or a liquid sample is irradiated with high energy x-rays from a controlled x-ray tube. When an atom in the sample is struck with an x-ray of sufficient energy (greater than the atom's K or L shell binding energy), an electron from one of the atom's inner orbital shells is dislodged. The atom regains stability, filling the vacancy left in the inner orbital shell with an electron from one of the atom's higher energy orbital shells. The electron drops to the lower energy state by releasing a fluorescent x-ray. The energy of this x-ray is equal to the specific difference in energy between two quantum states of the electron. The measurement of this energy is the basis of XRF analysis. Each of the elements present in a sample produces a set of characteristic fluorescent x-rays that is unique for that specific element, which is why XRF spectroscopy is especially useful for elemental analysis.

X-ray diffraction analysis (XRD) as a tool for non-destructive investigations of objects of art and archaeology is discussed. X-ray radiography e.g. is a standard technique widely used and accepted by art historians, archaeologists, curators and conservators as this method enables information about the manufacturing process and the condition of an object without "touching" the artifact. XRF and XRD enable a non-destructive determination of the material composition of artifacts and the determination of the crystalline structure of the components too. Air path systems and instruments with the micro-beam of X-ray and

synchrotron radiation were applied for the analysis of easel paintings, pigments in paint layers, glass artifacts and coins.

Hologram

New materials, and in particular the new laser recording technique developed at the Laboratory of Biophysics of the University of Muenster, enable the recording of high-resolution color holograms. The obtained (lateral) resolution for fine structures of scattering objects is below 3 μm. Thus, it is possible, with the help of a microscope, to investigate the 3-D microstructure of the object from a hologram, e. g. archaeological documentation and analysis. This system has great potential for a number of areas within Archaeology and Cultural Heritage including virtual museums, where 3D recreations of artifacts are visible to the viewer next to fragments. Or for site tours or visits to sites of historical interest where a 3D recreation model of the site is visible on top of the excavated remains. In museum visitors and students, as well as museum curators and faculty with expertise in art history and archaeology, to explore the potential of wearable AR in promoting meaningful engagement and learning with archeological artifacts in and outside the museum.



Hologram object

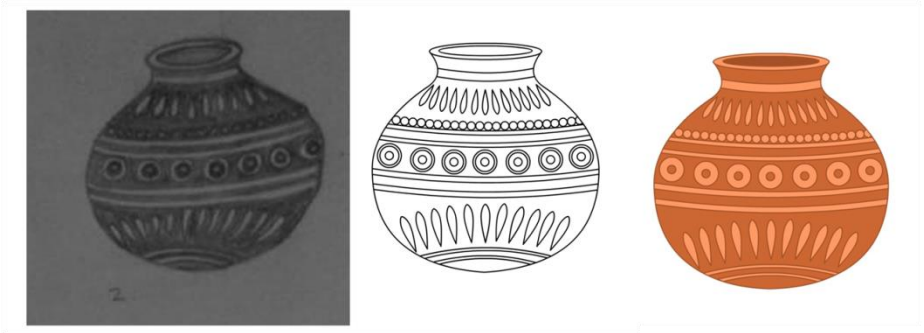
3D printing

3D printing and 3D scanning for museums and archeology are increasingly used in cultural preservation. 3D technologies provide museum curators, researchers and archeologists with new tools to capture in 3D ancient objects, artifacts or art pieces. They can then study, restore or simply archive them with much more details than traditional 2D pictures. It is even possible to 3D scan entire archeological sites to get a full 3D mapping, via drone or plane 3D scanning. As per preserving the cultural heritage, some historical sites are under danger, be that from armed conflicts, natural disasters or simply time erosion. It is possible to use 3D scanning to keep accurate 3D mappings of those historical locations. It's improving the accessibility to the museums and cultural heritage. 3D scanning opens the doors to virtual visits of museums. A person can visit an exhibition from the comfort of his own home. Restoring and replicating historical artifacts. 3D printing and 3D scanning can be used jointly

3D printed objects

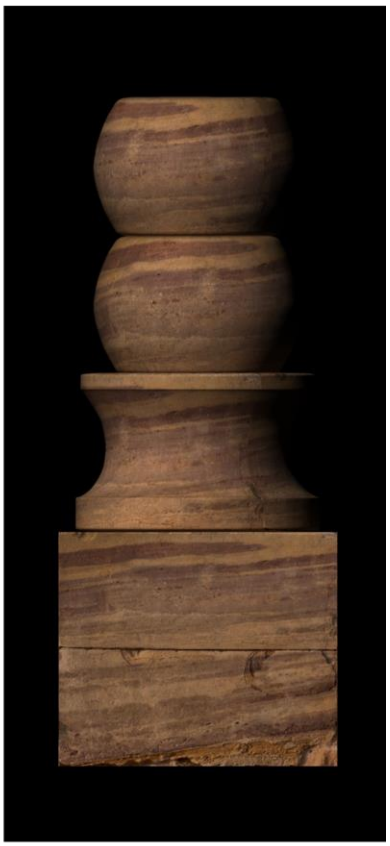
to restore damaged sculptures. Restorative 3D scanning, when 3D capture is used in the restoration process, is increasingly used in museums worldwide. To replicate an historical object, a 3D scan has to be done first. The file generated can then be used to 3D print a replica the piece, in plastic or other materials.

Some works samples and its final outputs.



Pots from Ajanta paintings

Pillars of Dholavira



E. Conclusion

As conclude the project we only come to an end of virtual assumption and further possibilities. In this particular case of digitizing this two objects gives us a way better view from the normal traditional photography. It's also provides the advance interpretation of those objects. In the data interpretation and the case of reconstructing the archaeological value or aspect, the digitizing is the only way to compose the story line of the history in a much updated and more detailed way from the traditional methods.

- Interpretation for the new generation it's a modern way of presentation.
- For all kinds of age group it is a virtual perspective.
- Making a 3D model is very easy to understand the measurements and the hidden features of any artifacts.
- We can recreate the ancient time into live form.
- By those types of models we can create any life size model by 3D printing technology by which we can replace the endangered artifacts or any antiquities from any museums or any sites or caves or from non leaving temples for its better protection and preservation.
- The data what we make by this process it's never been lost or damaged.

F. Bibliography:

1. Hologram – Archaeology and Heritage Digital Recording. (2019). Retrieved 19 September 2019, from https://digitalheritagerecording.wordpress.com/tag/hologram/

2. Antoine Arrighi, P. (2019). 3D scanning and 3D printing for museums and archeology. Retrieved 21 September 2019, from https://www.aniwaa.com/3d-printing-for-archeology-and-museology

3. 3D Laser Scanning and LiDAR. (2019). Retrieved 21 September 2019, from http://www.aocarchaeology.com/services/archaeology/survey/3Dscanning

4. Archaeological Applications of Unmanned Aerial Systems (Drones). (2019). Retrieved 17 September 2019, from https://core.tdar.org/collection/29462/archaeological-applications-of-unmanned-aerial-systems-drones

5. Baxter, C. (2019). Terrestrial Laser Scanning in Archaeology and Cultural Heritage Management. Retrieved 22 September 2019, from https://www.rdmag.com/article/2017/08/terrestrial-laser-scanning-archaeology-and-cultural-heritage-management

6. Nast, C. (2019). Archaeologists Don't Always Need to Dig—They've Got Drones. Retrieved 19 September 2019, from https://www.wired.com/story/archaeologists-dont-always-need-to-digtheyve-got-drones

7. Ltd, A. (2019). Archaeological Surveys Ltd. Retrieved 20 September 2019, from https://www.archaeological-surveys.co.uk/1/Home

8. Inc, U. (2019). How GPR is Used, Exploring Applications - US Radar. Retrieved 22 September 2019, from http://www.usradar.com/ground-penetrating-radar-applications.

9. Nummi, E. (2019). Technology Focus: X-ray Fluorescence (XRF) in Mining. Retrieved 22 September 2019, from https://www.thermofisher.com/blog/mining/technology-focus-x-ray-fluorescence-xrf-in-mining.

10. Journalistic flair, T. (2019). Six tools that are revolutionizing archaeology by helping us find sites without digging. Retrieved 26 September 2019, from https://theconversation.com/six-tools-that-are-revolutionising-archaeology-by-helping-us-find-sites-without-digging-51826.

11. Feagans, C. (2019). LIDAR From Self Driving Cars and Archaeology. Retrieved 23 September 2019, from https://ahotcupofjoe.net/2017/02/lidar-self-driving-cars-archaeology/amp.

12. Chiabrandoa, F. (2018).UAV PHOTOGRAMMETRY FOR ARCHAEOLOGICAL SITE SURVEY. 3D. *Virtual Archaeology Review, 9(18)*, 28-43.

13. Christina Pollalis, O. S. (2017). HoloMuse: Enhancing engagement. *TEI* (pp. 111-121). Japan: TEI.

14. Christopher H. Roosevelt, P. C. (2015). Excavation is Destruction Digitization: Advances in Archaeological Practice. *Journal of Field Archaeology*, 325-346.

15. G. Tucci, D. C. (2011). EFFECTIVE 3D DIGITIZATION OF ARCHAEOLOGICAL.*International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXVIII-5/W16*, 413-420.

16. Gabriele Bitelli, M. B. (2009). An Integrated Approach for the Use of GPS and GPR in Archaeological Sites: a case study at TilmenHöyük in South-Eastern Turkey .*ESTRATTO* (pp. 89-110). Italy: ALMA MATER STUDIORUM - UNIVERSITÀ DI BOLOGNA.

17. Gattiglia, G. (2015). From digitization to datafication.*MAPPA Lab – Università di Pisa*, 33-37.

18. Karasti, H. (2012). Exploring eScience for Archaeology: Digitalization of Archaeological Data in the context of Digital Curating .*Enriching Cultural Heritage* (pp. 10-14). Finland: Oulu University.

19. M. Schreiner, B. F.-S. (2004). X-RAYS IN ART AND ARCHAEOLOGY – AN OVERVIEW.*International Centre for Diffraction Data 2004, Advances in X-ray Analysis, Volume 47*, 97-102.

20. Nilsson, D. (2011). *The usage of unmanned aerial vehicles and their prospects in.*Sweeden: Master Thesis for master degree in archaeology,Institute of Archaeology.

21. S. GonizziBarsanti, F. R. (2013). 3D SURVEYING AND MODELING OF ARCHAEOLOGICAL SITES.*ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume II-5/W1*, 145-150.

22. Shott, M. (2014). Digitalization archaeology: A subtle revolution in analysis. *World Archaeology*, 1-9.

23. Smekalova, B. W. (2012). Magnetic exploration of archaeological sites. In B. S. Cristina Corsi, *Good Practice in Archaeological Diagnostics* (pp. 1-14). Switzerland: Springer International Publishing.

24. TatyananSmekalova, O. V. (2008). *Magnetic Surveying in Archaeology*. St. Petersburg: Publishing House of the Polytechnical University.