

New Approach for Digital Technologies Application in Heritage Architecture Conservation

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Abstract: Heritage is the memory of people for culture, arts, history, literature, customs, traditions and human innovations linked to the non-concept of our memory and it represents human creativity in architecture and our contribution to the enrichment of civilization which is linked to the tangible history of our culture. Cultural and historical attractions are important factors for the development of tourism, which stimulates the growth of heritage industry. Societies and people have many cultural heritage, historical architecture and heritage interior spaces, heritage which are considered great importance and ancient history. Therefore, the preservation of culture and heritage to the future is the responsibility of everyone from the degradation processes which arise from environmental factors, erosion, destruction and others. As cultural heritage is a vital element of modern society and the most important component of identity in modern times. Nowadays, the study of digital technology is an important field in the study of historical architecture conservation. In addition, the role of architects and designers in these processes is magnificent importance. Thus, the continuous evolution of digital technology creates new approaches to conservation science and documentation, leading to new methodologies which can restore the degradation of architecture and can maintain interior functions of the building. The main concern is the usage of technological solutions to preserve the architecture and interior spaces, as well as, studying the connection between restoration and documentation and their roles in conservation of architecture heritage. Focusing on various techniques to study, analyze and protect historical buildings is essential. As digital preservation forms multiple measures which shape cultural heritage, besides its importance and its social value.

The research studies important fields such as conservation, restoration, material science, documentation and media technology. It highlights essential challenges towards sustainable approaches in digital conservation and restoration. The study explains and promotes the objectives, principles and standards of preservation and conservation. It aims to provide a greater contribution towards conservation of the heritage and analyze the applications of digital technology in conservation heritage to link material science and nanotechnology, which do not harm and do not lose the value of heritage buildings in the long term. The problem of research is the deterioration and neglect of heritage buildings and the non-application of technological methods which contribute to the preservation of heritage effectively and a safe way. So that, the research studies the use of biological materials as a tool for heritage buildings and applications of advanced technology in the field of heritage buildings preservation. Furthermore, nanotechnologies and nanomaterials explore conservation, restoration of cultural heritage and preservation of heritage architecture.

The study sheds light on an innovative approach to architecture and interior design in building culture, in addition, challenge the gap between historical preservation of the heritage environment and conservation of natural resources. The research seeks to enhance heritage culture through modern digital technology. Therefore, the research includes the impact of nanotechnology, nanomaterials, 3D laser scanning technology, photogrammetry, virtual reality and many other techniques which is used to preserve heritage. As well as the analysis of digital innovations in architectural heritage preservation through the application of Nanotechnologies,

Nanomaterials, Nanoparticle and Virtual reality in the construction of cultural heritage in order to protect historical buildings and restore of heritage architecture. In conclusion, the research demonstrates the role of digital innovations in architectural heritage and technological trends in digital conservation techniques. Thus, the study of advanced 3D laser scanning systems, and virtual reality, which allows accurate documentation of locations in detail and provides complete information to preserve architecture through virtual 3D models.

Hence, this leads and enhances architects to benefit from the conceptual and methodological background of nanotechnology, the development of new nanomaterials and the analysis of other technologies which will further improve the performance of restoration architecture. The research concludes the clear relationship between material science and architectural heritage, accessing to green heritage and sustainable heritage. The identification and preservation of heritage is the first essential step to obtain an overview of the richness and diversity of heritage in a city or a region. The research concludes the virtual reality, digital models and their role in preserving heritage. In addition, Digital photogrammetry, laser scanning and other modern techniques can greatly assist the documentation of Cultural Heritage. Consequently, this paper provides approaches and standards of conservation of architectural heritage application. The study recommends the establishment of strict laws governing the preservation of heritage and the use of technological techniques without harming the heritage. These laws are tools that, if used properly, allow effective protection of heritage buildings. When dealing with a historical city or area, conservation should consider the nature and quality of urban planning, architecture, and non-built areas, with history as well as its function.

Keywords: Material science, Nanotechnology, Nanomaterials, Art conservation, Digital & physical preservation, Virtual reality, Historical attractions, Heritage attractions, Nanoparticle, Documentation, Simulation & virtual reality, Virtual Heritage, 3D Virtual Models, 3D Virtual Design Technology, Surveying, 3-D Modeling, Computer Based Visualization, 3D laser scanning technology, Digital photogrammetry, Green heritage, Adaptive reuse, Sustainable heritage, Restoration.

1. Introduction

Natural disasters such as earthquakes have caused great damage to heritage buildings (figure 1). The heritage is preserved in an unconscious manner and traditional methods of restoration, which lose the historical value of heritage buildings, works of art, Sculptures and many other fields of art which preserve heritage. Our society and our human behavior are changing because of the massive progress in technology and how we will live in the future, so that, new technologies have a great role in preserving the heritage in different arts fields (“International training program in built heritage conservation,” 2010). Cultural heritage is an expression of the life ways developed by society and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values (“What is Cultural Heritage,” 2014). Many countries have a cultural dimension , a great architectural in its heritage buildings. Heritage buildings are structures of a distinctive architectural style from a single or collective structure which reflect the characteristics of a certain time period or an automatic structure and reflecting a local , rare , unique environment, national history, events, historical figures or a tourist attraction characterized by its artistic value. In addition, the contents of those buildings of accurate technical details are very important to conserve them, contribute and increase attention to them.

1.1 Heritage of traditional buildings in changing surroundings (Why heritage is important?)

Heritage is collective property which tells the history of a people, city or territory, and is passed on from generation to generation. Heritage makes it possible for generations to understand their place in history to better deal with the steady mutations of society: it is the element of stability in a rapidly changing world. All civilizations have left many legacies to today's world. The study of this heritage creates a new vision for today and better prepare for the future. The conservation of heritage is complex and it must be dealt with through multiple disciplines. However, for various reasons, the value of this heritage has not always been recognized. For a long time, the heritage has been neglected, abandoned by its owners so their lost whole parts of the local heritage which often threatened by the influence of natural forces (rain, wind, vegetation ...) (Figure 1) (Figure 2) (Figure 3).



Figure 1. Demolition and neglect of architecture heritage in El Max, Alexandria and Villa Ambron, house to the great British author Lawrence Durrell (“Villa Ambron,” 2018).

1.2 Material and intangible heritage

Material and intangible heritage are however closely related. The research deals the conservation and the opportunities offered by digital technologies: Conservation is a general concept which includes strategies to protect and promote heritage, materials science, digital applications, virtual reality, digital photogrammetry where research focuses on architectural heritage (Brusaporci, 2017). Heritage can be divided into two main categories which include a material, tangible form such as archaeology, art, architecture. In addition, another form is “Intangible Cultural heritage”. So that, the research shifts from a study in the concepts of "conservation" to the constantly evolving idea of "heritage". Then it refers to the importance of heritage building as a reference for the study of tangible and intangible heritage.

1.3 The era of modern digital transformation in Digital heritage

The continuity of digital heritage is essential, in addition, the preservation and restoration of cultural heritage is a difficult field (Balliana, Ricci, Pesce, & Zendri, 2016). Digital heritage consists of unique resources of human knowledge and expression. Many of these resources have lasting value, importance and thus constitute a heritage which must be protected, preserved for present and future generations. The purpose of the digital heritage preserving is to remain accessible to public (UNESCO, 2003). In addition, preservation of stone heritage is a delicate and complex challenge. It is necessary to choose the appropriate materials and procedures for proper conservation treatment (Sierra-Fernandez, Gomez-Villalba, Rabanal, & Fort, 2017). Hence, heritage conservation is an advanced practice, linking many disciplines between the technical, engineering and cultural sectors. it is a complex process, requiring multiple information to be applied at multiple levels, besides, using multimedia (Srinivas,

2018). This exchange has become an essential role in the interpretation, maintenance of natural, cultural heritage sites and sustainable management, as well as understanding issues and exploring the methods adopted in this field. The research highlights the most innovative trends in digital conservation techniques and architectural backgrounds (Brusaporci, 2017).

1.4 Innovative reuse of cultural heritage - challenges and opportunities in the digital world

Preserving heritage can be conducive to stimulate tourism and attract customers. Communities have a large stock of heritage buildings (“What is heritage conservation? A brief overview,” 2018). The research depends on challenges which confront architecture heritage, the use of latest technologies and bio-materials for protection, conservation, preservation, digital expansion, visualization, digital applications in preserving architectural heritage and interior spaces. The research demonstrates the enhancement and consolidation of advanced tools within digital heritage research and application of technology in innovative reuse of architecture.

2. Challenges and Problem

The research deals the impact of the relationship of digital technology in the preservation of architectural heritage and heritage buildings. In addition, there are many challenges which face heritage in merge technology in architecture heritage to explore innovative approach in architecture and interior spaces and conserve to green heritage. Consequently, the research discusses a range of digital and biological technologies and their role in preserving the architectural heritage. These techniques constitute new methodologies in the process of conservation, restoration and revival of heritage. The process of preservation of heritage interferes with many rules and accurate methodologies. The competent authorities must be united to preserve the heritage, requiring the overlap of all specialists.

Important standards in heritage preservation which include:

1. Does not lose its value and importance.
2. Cannot hurt the long-term impact.

The problem of research is the lack of full awareness by architects and designers of the way heritage is revitalized through restoration, reconstruction, repair, or adaptive reuse. Digital technologies and bio-materials solve many problems in heritage buildings which need restoration, maintenance or re-adaptation and green heritage. In addition, it is important to follow many methods which do not lose the importance of the impact and do not harm in the long run without a clear vision followed by the team in charge of preserving the impact.

3. Objectives

- This paper is to present and analyze some of technological methods to preserve architecture heritage. In addition, it preserves the value of buildings and thus increases their value by protection their original form and architectural elements, preferring instead to replace them. The research aims to revive the architectural heritage without damaging it in the long run to clarify the importance of using technology to preserve the heritage without losing its value using sustainable natural technologies and materials which lead to the green heritage to conserve natural resources.
- Study the relation between material science, architecture heritage and the effective impact of Nanotechnologies in conservation of heritage architecture.
- Analyze the applications of advanced technology in the field of preservation of heritage buildings to maintain of heritage buildings and protect them for tourism.
- Focus on the digital role where technologies can be useful tools for preserving heritage and it shows how digital technologies adapt into conservation issues to protect heritage.

4. Research Methods

Architectural heritage is defined through "continuous processes of modification and transformation across time (Brusaporci, 2017). Strengthening theoretical knowledge about architecture is essential in linking conservation practices among specialists in natural and cultural heritage. Therefore, it provides designers and architects with basic knowledge of heritage conservation and management, including concepts, perspectives and methodologies associated with the interpretation and analysis of architectural heritage. So that, any project for conservation is based on knowledge and understanding the historical and aesthetic value. The research is divided into three sections through successive processes and integrated to each other, including conservation, materials science and documentation. The research studies several interrelated fields to preserve heritage and access to a green heritage.



Figure 2. Lawrence Durrell's Tower in Alexandria and the extreme neglect of architectural heritage.



Figure 3. villa Aghion design after the collapse in Alexandria.

5. FIRST SECTION: Heritage Building Conservation and restoration

Conservation is the first stage in the preservation of heritage, which determines the appropriate method to protect the architectural heritage. Architectural conservation focuses on the protection of heritage from environmental damage to materials, form and structure, combining architectural design between science, arts, crafts and technology to achieve the desired result (“Heritage Building Conservation,” 2018). **Digital Conservation & Restoration** is based on conservation ethics and restoration principles.

5.1 Digital techniques and methods for conversation heritage in architecture

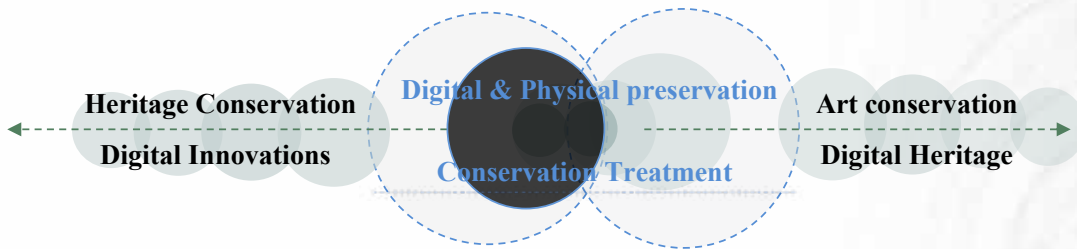


Figure 4. Diagram of elements for digital conversation heritage.

5.2 Use of new digital techniques conserving architectural heritage

Digital techniques are applied naturally to our lives, daily work and culture. Artists, designers, architects, musicians, theorists and cultural institutions increasingly rely on digital technologies, data production, storage and distribution of digital content in different ways. Digital technology seems to be fully integrated into scientific analysis processes which preserve historical architecture.

5.3 Historical Heritage Criteria

Heritage Conservation could be divided into three parts:

1. Natural Heritage.
2. Cultural Heritage (monuments, group of buildings, Sites).
3. Combination of natural and cultural heritage.

5.4 New Methodologies for the Conservation of Cultural Heritage

1. Conservation Treatment

2. Identification, Restoration



Figure 5. Identification, conservation, restoration of outdoor metallic sculpture of the Library of Congress (LOC) from the XIXth to the beginning of the XXth century (“The Library of Congress (LOC),” 2018).

1. CONSERVATION

A. STONES CONSERVATION

LIMESTONE SCULPTURE CONSERVATION – RIVERSIDE CHURCH project in New York, NY, 2008. Sculpture Conservation, Deterioration of Sculpture. The architecture was built of limestone and ornamented with a group of sculptures with contemporary art deco style of its time. The project explained before and after the restoration where a plan has been developed to treat the damage, prevent further decay, and restore the missing elements. Molds were taken from weak attributes to be used in replication. The cracks and losses were drilled back to the sound stone while preserving the original carved surfaces, then the losses were rebuilt again to restore the lost features. After processing, the statues were combined (“LIMESTONE SCULPTURE CONSERVATION - RIVERSIDE CHURCH project,” 2008).



Figure 6. Modeling Replacement for Sculpture Losses, Sculpture Conservation, Face Replica. The project showed a hard shell formed on the outside of many sculptures, while the basic stone materials have been eroded leaving only loose grains. The cracks formed on the surfaces to expose the damaged interior to the water and caused the full elements to fall (Figure 7). **Materials** / Limestone, Mortar.
Services Provided / Research-Documentation, Conservation Treatment.



Figure 7. Riverside Church Sculpture Before Treatment, Riverside Church Sculpture After Treatment.



Figure 8. ORNAMENTAL TERRA COTTA RESTORATION - RINGLING MUSEUM OF ART project in John & Mable Ringling Museum of Art in Sarasota, FL, 2015-2017.

Research depended on exposure to salt spray with strong infrared rays of the sun, erosion of structural metal structures and cracking. It provided recommendations for stabilizing and treating the balcony where it was carefully dismantled, in addition, the exposed steel substrates were cleaned of corrosion. The crushing units have been removed for repair, besides, it will be replicated according to a new design which allowed for thermal expansion during extreme temperature fluctuations. The facade of the building was restored and painted to suit the color of the adjacent paint, then the terrace was reassembled (“ORNAMENTAL TERRA COTTA RESTORATION - RINGLING MUSEUM OF ART project,” 2017).

Materials / Terra Cotta.

Services Provided / Conservation Treatment, Surveys-Condition Assessment.

Services Provided / Research-Documentation, Surveys-Condition Assessment, Contract Drawings-Specifications.

B. METALS CONSERVATION



Figure 9. Diagram of metal conservation stages.



Figure 10. The team tested various techniques to safely remove unwanted corrosion products, samples from a variety of coatings to match the original finish, and performed tests to repair the missing original paint areas.



Figure 11. SENATE CHAMBER METALS CONSERVATION – KANSAS STATE CAPITOL project in Topeka, KS, 1999.



Figure 12. Bronze Columns at the Kansas State Capitol Senate Chamber, Metal Architectural Elements at the Kansas State Capitol Senate Chamber, Bronze Conservation Treatment. The Senate Chamber was a unique artistic work ornamented in 1885. The round windows, which feature faceted stained glass, were imported from France. The walls were decorated with various exotic materials from all over the world. The research team reviewed historical documents, besides, conducted on-site tests to determine the original appearance of metals and their degradation and cause nature (Figure 11). The 28 columns were ornamented with ornate panel, decorative ornaments and wall grids so that all surfaces could be accessed. Old protective coatings and corrosion products have been removed from copper, silver and the missing parts have been removed and re-installed. Large areas of loss of paint and new castings were replaced on site using brushing technique (Figure 12) (“SENATE CHAMBER METALS CONSERVATION - KANSAS STATE CAPITOL project,” 1999).

Materials / Electroplated Cast Iron, Stamped Copper, Cast Bronze, Nickel/Silver.

Services Provided / Surveys-Condition Assessment, Research-Documentation, Testing-Analysis, Conservation Treatment.

2. RESTORATION



Figure 13. Development, restoration and reviving of Darwish Theater Project. Dome of Whirling Dervishes Ceremony hall at the Mevlevi Tekke, a meeting hall for the Sufi order and Whirling Dervishes, Cairo, Egypt.



Figure 14. Darwish Theater consists of a round wooden platform surrounded by a circle and surrounded by a wooden railing. The second floor is a wooden staircase which leads to irregular spaces and it have been allocated for the audience and spectators. The Hall is based on 12 columns, eight windows and eight decorative units. The building combines the Ottoman and Mamluk styles and it is divided into three spaces (Figure 14).

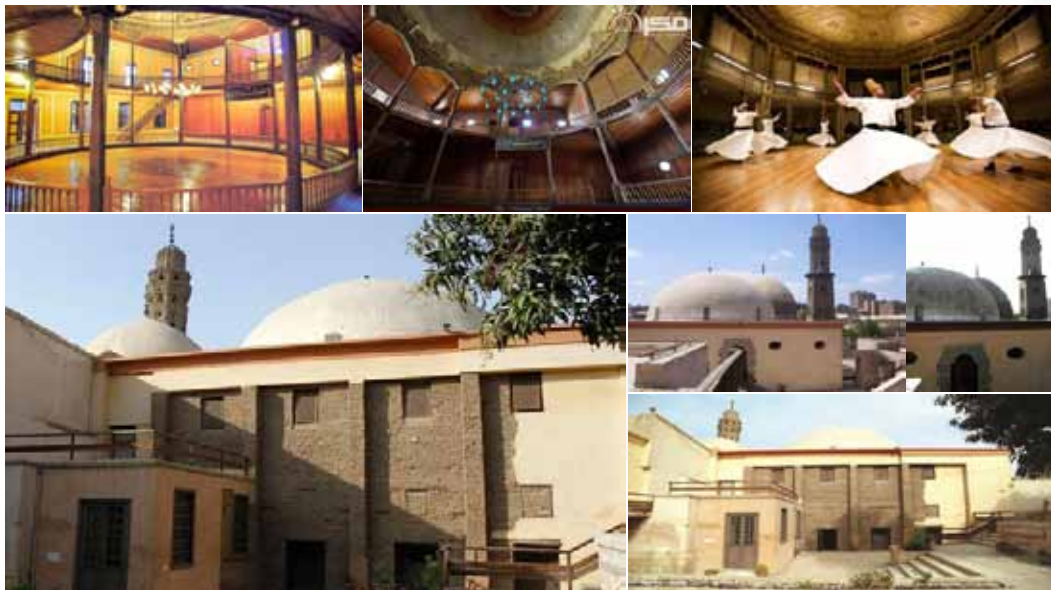
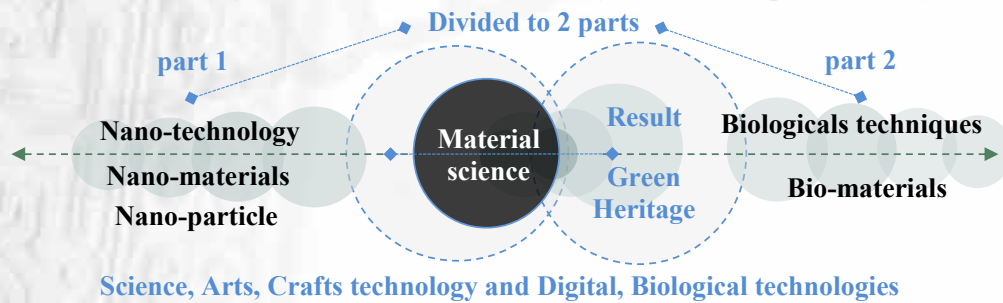


Figure 15. The center of the theater from the ceiling dome is one of the most important signs of Tikkiyah, it is built on twelve wooden columns, each containing a name of the twelve imams of the Muslim Shiites, followed by rectangular areas containing cumulative writings in Arabic letters. The interior of the dome is decorated with natural landscapes, including Turkish statues, flags, floral motifs and many illustrations of the Sufi philosophy on which the mulatto method is based (Figure 15).

6. SECOND SECTION: Digital Trends and Cultural Heritage
[Material science and architecture heritage]

There are many methodologies to preserve and protect the heritage through digital and biological technologies which reflect sustainable and more environmentally preserving heritage leading to green heritage. Instead of building on nature, biological materials and processes will be integrated into traditional engineering materials and processes (Figure 16).



Science, Arts, Crafts technology and Digital, Biological technologies

Figure 16. The relationship between material science and conservation of heritage.

| The use of biological materials as a tool for heritage buildings. Methodologies for cleaning, consolidation and protection operations within cultural heritage application to reach sustainable heritage | | |
|---|---|--|
| Technique/ Description | Technique/ Description | Technique/ Description |
| <p>1. Cleaning</p> <ul style="list-style-type: none"> ▪ Cleaning is usually the most expensive process in the restoration project. ▪ Solvents, whether aromatic or non-aromatic, and other cleaning products (ie, pickled agents, light and strong acids and bases) are used extensively in maintenance and applied to various materials such as plates, mural, etc. | <p>2. Microemulsions</p> <ul style="list-style-type: none"> ▪ Microemulsions are used as cleaning factors mainly on wall paintings and stones, because of their ability for control and transparency. ▪ Micro emulsifiers can be considered green because they require a small amount of solvents, thereby reducing their toxicity and environmental impact. | <p>3. Bio-cleaning</p> <ul style="list-style-type: none"> ▪ Bio-cleaning is a biological and sustainable alternative to conventional chemicals and mechanical cleaning of art works. ▪ Recently, the use of microorganisms for cleaning purposes has been tested successfully on undesirable materials, often found on art work surfaces, such as soluble salts and polymers. |
| <p>4. Ionic liquids</p> <ul style="list-style-type: none"> ▪ Ionic fluids are used as valuable substitutes for dangerous cleaning methods in the preservation of art works. One of the basic applications is a green alternative to cultural heritage. | <p>5. Laser</p> <ul style="list-style-type: none"> ▪ The laser has been used as an eclectic and environmentally friendly method of cleaning, because it cannot change or affect the surface of artifacts on a variety of materials, such as wood, metal, paper, stone, easel plates and wall paintings. | <p>6. Gels</p> <ul style="list-style-type: none"> ▪ Gel use as a supporting material or as an effective cleaning product in cultural heritage applications. High viscosity allows the release of solvents gradually, which reduces solubility. |

| | | |
|---|---|---|
| <p>7. Consolidation</p> <ul style="list-style-type: none"> Consolidation is a very difficult and sensitive process in conservation and restoration, as it can cause undesirable effects, such as yellowing, and uneven distribution of support. Most synthetic products (such as acrylic polymers, vinyl, silicon, etc.). | <p>8. Nanotechnologies</p> <ul style="list-style-type: none"> Nanotechnology has become increasingly important in the care of heritage, which can facilitate the operation of self-cleaning, anti-microbial treatment, or the protection of materials (Figure 17) (Kroftová, Šmidtová, Kuřitka, & Škoda, 2017). | <p>9. Bio-consolidation</p> <ul style="list-style-type: none"> Bio-consolidation is a new methodology based on selected microorganisms capable of settling stone materials and producing inorganic compounds (Figure 18). |
| <p>10. Protection</p> <ul style="list-style-type: none"> Innovative methodologies have been applied from the application of nanoscale polymerization and TiO₂ coatings. | <p>11. Bio-polymers</p> <ul style="list-style-type: none"> The use of bio-polymers may have advantages in terms of ecological compatibility, reversibility and biodegradability. | <p>12. TiO₂ nanoparticles</p> <ul style="list-style-type: none"> TiO₂ uses nanoparticles as self-cleaning and anti-microbial. |
| <p>13. Infrared Reflectography</p> <ul style="list-style-type: none"> High resolution multispectral scanning over a wider range of the electromagnetic spectrum can be undertaken by art analysis and research. It provides information the artist's painting process, and may help with problems of attribution. | <p>14. Ultraviolet Fluorescence Photography</p> <ul style="list-style-type: none"> Photography taken under ultraviolet illumination is used to record information about the artist's use of medium, pigments and varnish, in addition, recording areas of retouching. | <p>15. living concrete</p> <ul style="list-style-type: none"> The problem with traditional concrete is the formation of cracks. This has negative consequences for the durability of the material. It produces the biology of limestone to heal cracks and appears on the surface of concrete (Figure 21) (Figure 22) (Jonkers, 2014). |

Table 1. Methodologies to preserve and protect the heritage through digital and biological technologies (Balliana et al., 2016).

6.1. MATERIAL SCIENCE: NANO-TECHNOLOGY (PART 1)

6.1.1 Application Nanotechnologies in digital Conservation of Heritage Architecture

The impact of Nanotechnologies in Conservation of Heritage Architecture

1. Safe-by-Design nanotechnology for safer cultural heritage restoration (Figure 17).
2. Facilitate the cleaning of contaminated surfaces and self-cleaning.
3. Anti-microbial treatment.
4. The protection of materials from the negative effects of ultraviolet radiation and others.
5. Focus on the different types of nanoparticles currently used in the production of conservation (Figure 18).
6. Treatments with improved material properties and new functions.



Figure 17. Nanotechnologies and nanomaterials explore conservation, restoration of cultural heritage and preservation of art works.

6.1.2 Nanotechnologies techniques for conservation heritage

1. Nanoparticles.
2. consolidation process.
3. Nanoparticle can be effectively used to consolidate stone and paintings.



Figure 18. The restoration and conservation of a painting by nanotechnologies. Effect of consolidation process on works of art. before treatment; after consolidation (Figure 18). Nanoparticles are very small particles, with a dimension comprised between 1 nm and 100 nm.

6.1.3 Hydroxide Nanoparticles

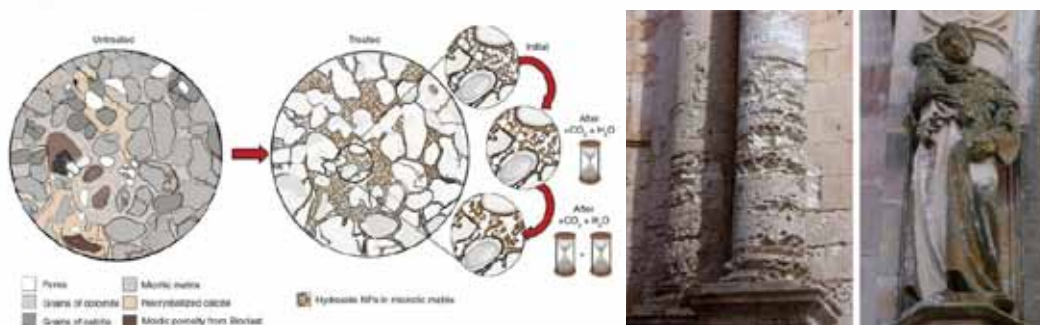


Figure 19. Thin film of dolostone before and after treatment with hydroxide nanoparticles.

Figure 20. Degraded stone heritage showing: salt weathering of building stone, visible microbial growth and staining (Sierra-Fernandez et al., 2017).

6.2. MATERIAL SCIENCE: BIO-TECHNOLOGY (PART 2)

6.2.1. Bio-materials and heritage conservation

Biotechnology plays a vital role in the preservation of architectural heritage and it is closely linked to the conservation process. In addition, it can preserve the heritage without harming it in the long run and can treat the effects of natural factors to reach a green heritage (Figure 21).



Figure 21. Self-Healing concrete can repair its own cracks with bacteria (“Self-Healing Concrete,” 2016). Figure 22. The living concrete which can heal itself with this self-healing concrete, buildings repair themselves by closing the small cracks attributed to the entry of gases and liquids which can affect their durability (Tziviloglou, Pan, Jonkers, & Schlangen, 2017) (“living concrete,” 2016).

7. THIRD SECTION: Virtual technology, Documentation and Heritage conservation

Digital technologies for surveying, modeling and representation

This section studies Digital techniques for surveying, modeling and representation which have produced significant methodological changes in conservation heritage. In particular, documentation, laser scanning, photogrammetry, virtual reality, advanced software for modeling, data analysis, and computer-based visualization have transferred a historical process of knowledge towards the use of complex 3D models (Brusaporci, 2017).

1. Digital Documentation
 2. Digital photogrammetry
 3. Laser scanning
- [Main techniques for digital application in heritage architecture conservation]

7.1 The virtual reality and its role in preserving heritage

The research uses virtual reality to preserve heritage (Ioannides, M., Martins, J., Žarnić, R., Lim, 2017). Digital transformation may play a substantial role in protecting this heritage. It is important to study digital technology in finding new solutions to preserve and document architectural spaces (Figure 23) (“Digital innovation can enhance cultural heritage,” 2018).

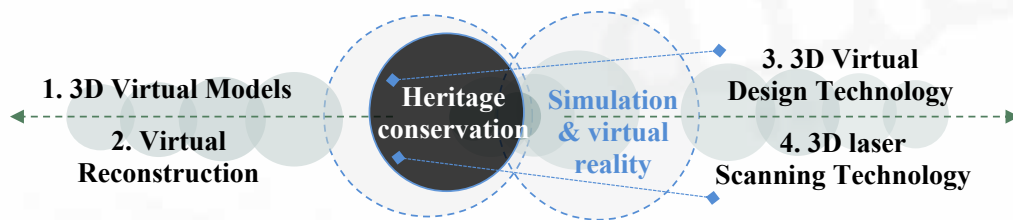


Figure 23. Diagram of virtual technology techniques and heritage conservation.

7.2 Digital Documentation of cultural Heritage

Documentation, digital Photogrammetry, laser scanning and other modern technologies facilitate creation, control and dissemination of accurate 3D models which can help conservatives in cultural heritage. They can offer higher and deeper accuracy to address new situations which may not be technically or financially accessible (Figure 23).

7.3 Digital innovation can enhance cultural heritage

- **Digital technology** is not just a new tool to visualize, explore or consume cultural heritage, otherwise, it can also help in conservation efforts. Digital documentation of heritage can take many different forms and use a wide range of technology (“Archaeology,” 2018).
- **Virtual Heritage** is “the utilization of technology for interpretation, conservation and preservation of Natural, Cultural and World Heritage” (Brusaporci, 2017).
- **Virtual Reality** bases on a total-body immersion in a computer-generated environment.
- **Photogrammetry** is “the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording and measuring”.

7.4 The use of virtual 3D presentations in the conservation of architecture heritage

Robotics, computer science and virtual reality have been applied to the study of cultural and heritage sites. As well as accurate documentation of cultural heritage is necessary to protect it, in addition, scientific studies carried out during the process of restoration and renovation (Figure 25). Proximity imaging has been used successfully to document cultural heritage. With recent advances in computer and information technology, this traditional method of near-term digital imaging has been replaced. Laser scanning is another technique which in recent years has become increasingly common for documents and provides highly dense 3D dots. Hence, 3D form and digital image can be created directly (NaciYastikli, 2007).

7.5 Visualization & Simulation

Once the heritage site of the architecture and interior spaces is examined, it is translated and produced realistic images. New 3D modeling designs can be visualized or simulated in a virtual reality environment (“Visualization & Simulation,” 2018).



3D LASER SCANNING / 3D MODELLING / 3D INSPECTION / 3D APPLICATIONS

Figure 25. Digital survey of cultural Heritage (“Digital survey of cultural Heritage,” 2018).

7.6 3D Laser Scanning

3D Laser Scanning is a complex scan for locations in a 3D image with minimal downtime. It gives the possibility to design potential improvements in the digital scene (Figure 24). It is easy to scan huge sites with complex architectural features. However, conversion of this data into modeling of micro-structure information remains a challenge (Figure 25) (Figure 26) (Figure 27) (Figure 28).

7.7 Some of projects for application Virtual technology, Documentation and other techniques in heritage conservation

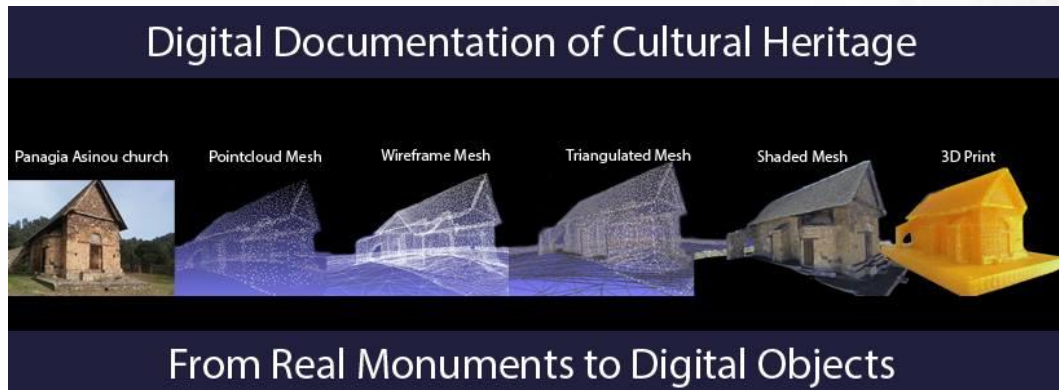


Figure 24. Digital Documentation of cultural Heritage from real building to digital objects (“Initial Training Network for Digital Cultural Heritage,” 2018).



Figure 25. 3D Laser Scanning Architecture. Figure 26. A visualization of data collected at Ecab (“Digital Heritage Conference in Granada, Spain,,” 2015).

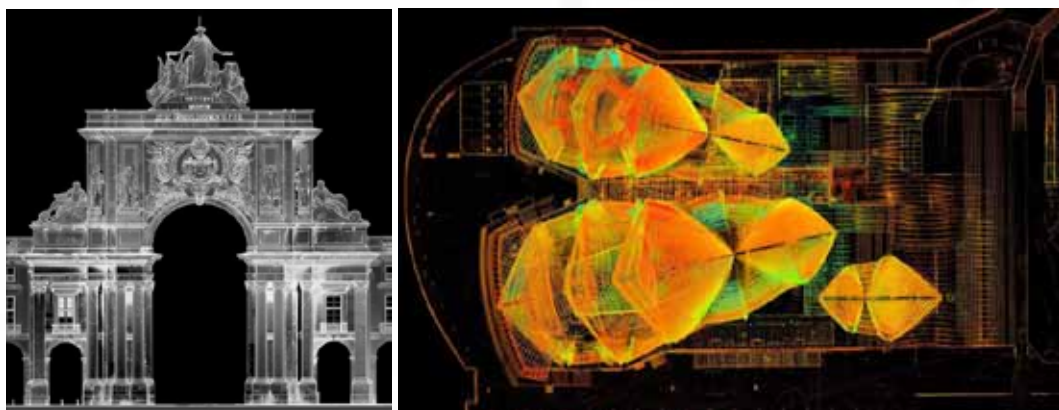


Figure 27. The 3D laser scanning survey of the Arco of Rua Augusta. Figure 28. The Sydney Opera House project took more than 800 laser scans of the interior and exterior, and 56,000 digital photos, documenting 13 billion measurable points on the structure using cutting-edge, laser-mapping technologies (“3D laser scanning,” 2013).

7.7.1 The power of 3D scanning

The study of digital documentation techniques provides accurate data for architectural heritage and interior spaces. Hence, the Specialists can determine the safe means used either through conservation, restoration or use of materials science, which includes nanotechnology technology and biological materials (Figure 29) (Figure 30) (Figure 40) (Figure 42).



Figure 29. 3D Laser Scanning Architecture and a visualization of data collected at Ecab.

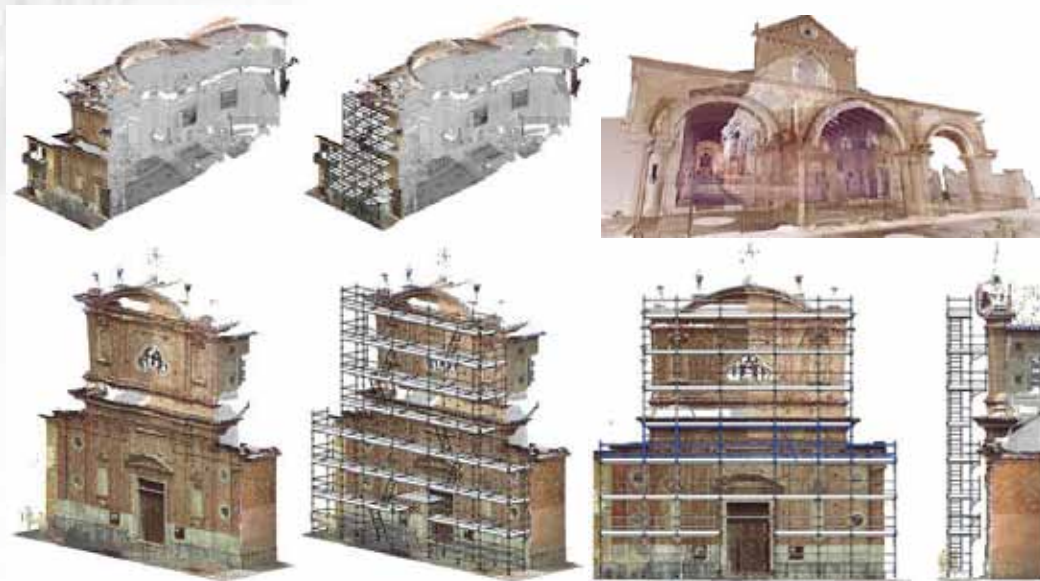


Figure 30. Digital photogrammetry and laser scanning (“Digital photogrammetry and laser scanning,” 2018) (“3d scanning,” 2018).

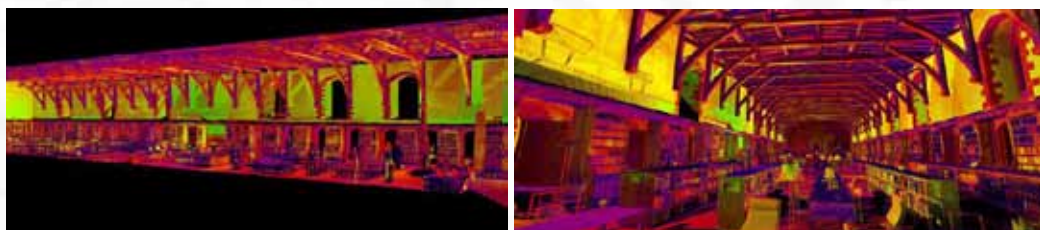


Figure 32. Digital Surveys 3D laser scanned the Cathedral cloisters and Monks Dormitories (“The Cathedral cloisters,” 2018). The digital surveys completed a metric laser survey of the UNESCO World Heritage site at Cathedral cloisters, which it is the greatest example of Norman architecture in England. The survey required high-density point data to be captured from several key areas within the cathedral (Figure 33). It began in 1093 and ended largely in 40 years. It was the only cathedral in England which retained almost all its craftsmanship, in addition, it maintained the integrity of its original design.



Figure 33. As part of the conservation plans as well as providing a quick snapshot at the time, the laser scanning was used to create the detailed geometry and horizontal projections of the cathedral then determined the process of processing the church. A three-dimensional laser scan was performed over 10 days in the cathedral using a Faro Photon120 laser scanner (Figure 34).



Figure 34. All scans were performed at a very high density and color photographs were also taken in each scan setting. All individual rooms were divided into groups and sub-clusters.

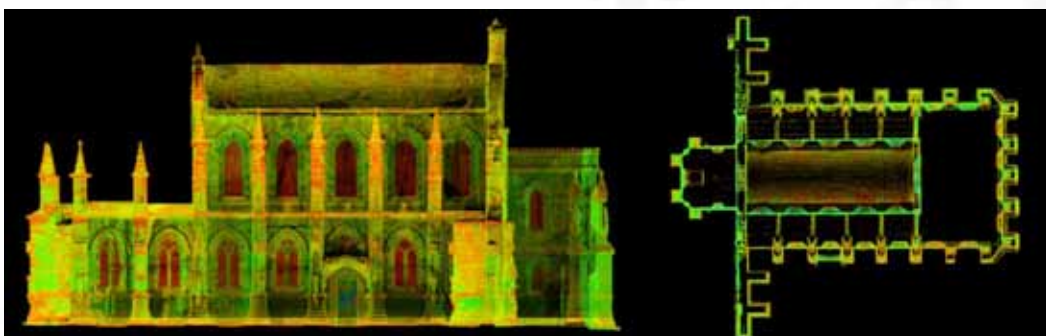


Figure 35. Center for Digital Documentation and Visualization, Glasgow (“Digital Documentation,” 2018). Rosslyn Chapel was a medieval building which has been described as a "treasure of stone", a protected historic building. It was still used as a place of worship, as well as it was an international tourist destination, attracting more than 150,000 visitors annually (Figure 36).



Figure 36. Rosslyn Chapel, 8 billion points scanned over 3 days by the Centre for Digital Documentation and Visualization, Glasgow. Since 2008, the Digital Documentation and Imaging Center had worked to document the interior and exterior of the Rosslyn Church and its land used advanced laser. Scanning and panoramic techniques were 360-degree. 3D laser scanning data had been developed to become a virtual 3D model of the chapel. Then it had been explored the outer and inner part of the church used the 3D interactive model.



Figure 37. Elevations of Digital Documentation.

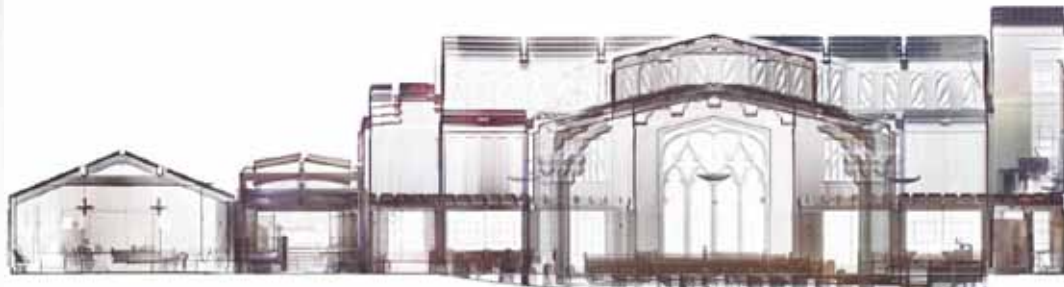


Figure 38. Section of church to document the interior heritage.

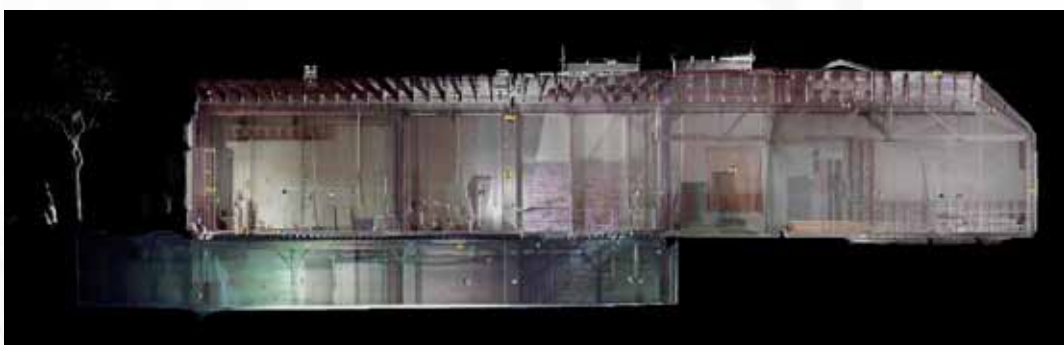


Figure 39. Section of historical building through 3D laser scanning technology.



Figure 40. Virtual 3D model of documentation interior space.



Figure 41. San Francisco Bay Area 3D Laser Scanning Projects (“3D Laser scanning,” 2018).



Figure 42. Sections of Churches, temples and shrines, may adapt to the needs of culture, or suffer from neglect and destruction, as in the past. old cinematic "palaces" may become centers of performance or severely cut in the inner shopping malls (“3D Laser scanning,” 2018).



Figure 43. Sections of 3D laser scanning data.

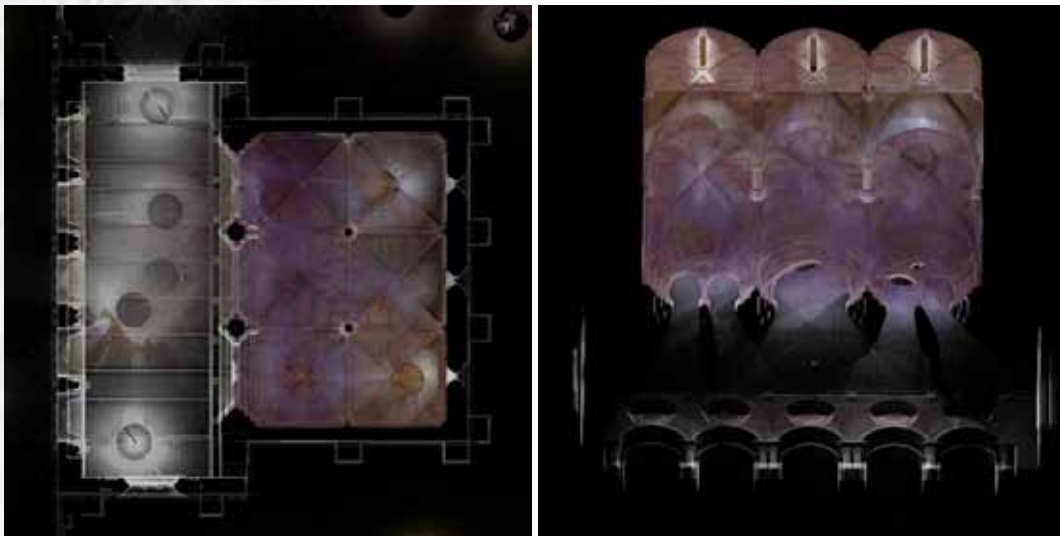


Figure 44. Plan and perspective of Cistercian church project which included the reconstruction of the church and dates to the late 12th century.



Figure 45. The internal scan of the church was completed before it became too dark to continue without artificial light (“The Abbey of New Clairvaux,” 2018).

Applications of digital technologies in heritage architecture and interior conservation

8. Officials of the Wieliczka salt mines (UNESCO World Heritage Site) project

The main objective of this project was to determine the possibility of using laser scanning technology to assist in ongoing maintenance work within the mine (Figure 46) (Figure 47) (Figure 48) (Figure 49) (Figure 50) (Figure 51).

TOTAL TIME SPENT

8 days onsite 2 persons team, 40 days data processing.

FINAL PRODUCT

Registered point cloud, Truview, CAD drawings, orthoimages.



Figure 46. Plan of Wieliczka project in Salt Mine, Poland.



Figure 47. The project focused on corridors and underground rooms, both inside and outside the tourist route.



Figure 48. A three-dimensional film was also produced entirely for photographic purposes.

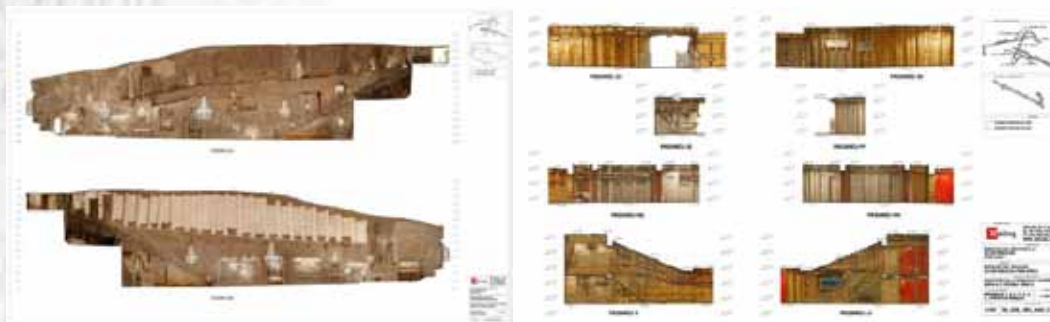


Figure 49. The research commissioned laser scanning technology.



Figure 50. Sections of project after 3D Laser scanning application.

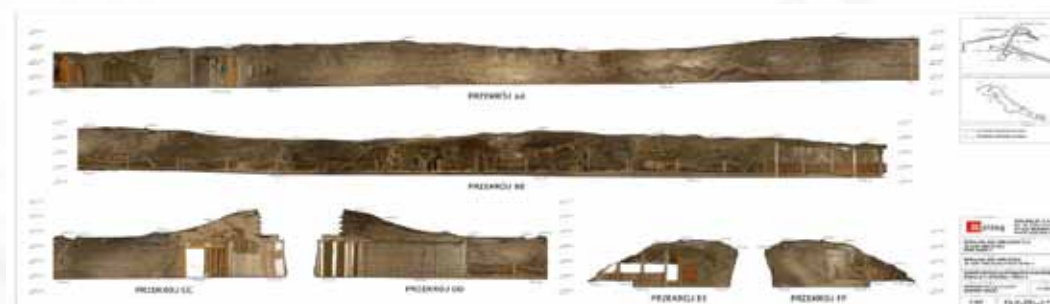


Figure 51. The film allowed the viewer to visualize the mine layout, which was difficult in the real world (“3D laser scanning,” 2018).

9. The Uniejów Castle project

The project was intended to document the current state of the exterior facades buildings to be used as the basis for the reconstruction / maintenance work planning (Figure 52) (Figure 53) (Figure 54) (Figure 55).

TOTAL TIME SPENT

1 day on site, 20 days for processing.

FINAL PRODUCT

CAD drawings and orthoimages of external facades.

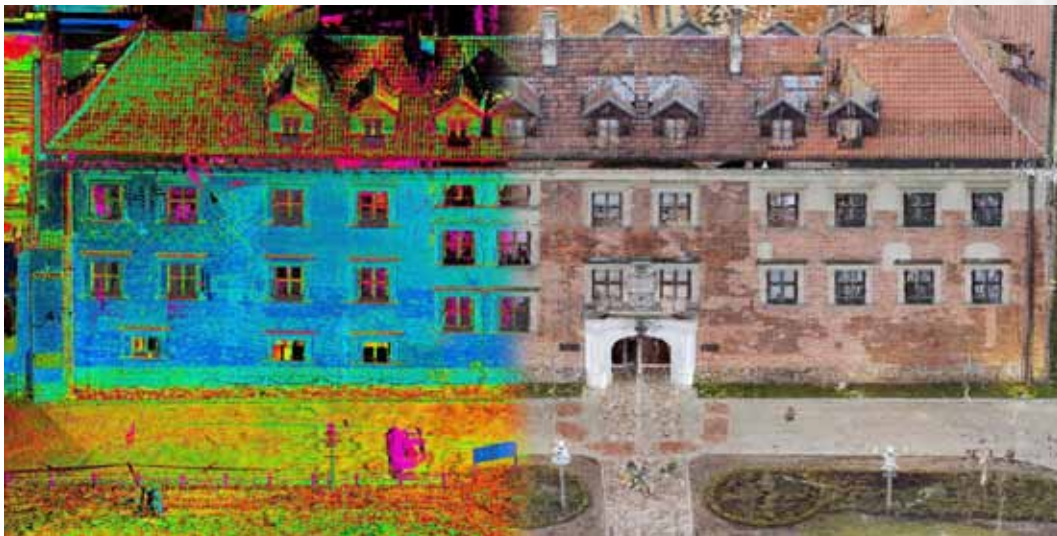


Figure 52. Laser scanning of Uniejów Castle in Uniejow, Poland (“Uniejów Castle,” 2018).

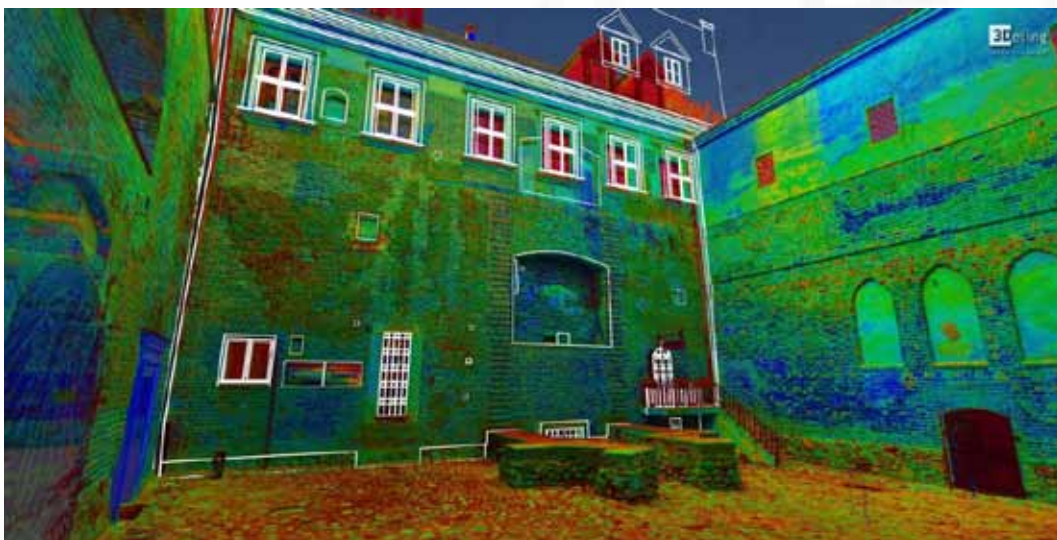


Figure 53. The building was scanned at the highest resolution settings for all external interfaces. Then, it was covered by the CAD with Orthoimages to show the full potential of laser scanning (“3Ddeling - 3D Laser scanning,” 2018).



Figure 54. Elevations of CAD drawings were completed from the same dataset.



Figure 55. Survey work and a three-dimensional visualization of the site were produced.

10. Historical façade project

The purpose of this project was to record the historical façade of this building for registration purposes and specifying requirements of the project for heritage conservation (Figure 56) (Figure 57).

TOTAL TIME SPENT

1 day on site (10 scans), about 10 days processing in the office.

FINAL PRODUCT

Orthophotos, 3D BIM models.



Figure 56. Historic Elevation in Plock in Plock, Poland (“Historic Elevation in Plock,” 2018).

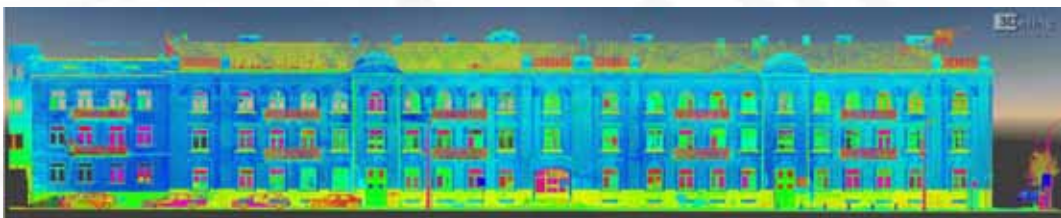
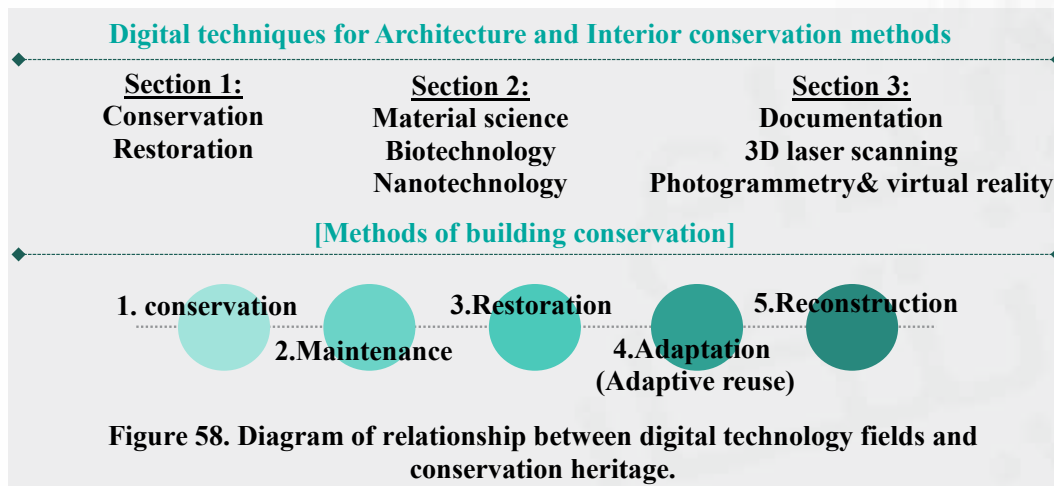


Figure 57. Many techniques have been employed to collect a comprehensive data set. The scan was used to add geometric features (“3D laser scanning,” 2018).

11. Results and discussion

The process of heritage preservation determines the exploration of architecture and interior spaces then the implementation of treatment plan for the conservation, maintenance and restoration of heritage. Digital technologies and biotechnology facilitate the preservation of heritage. The research discussed the importance of preserving architectural heritage, providing a great opportunity to stimulate tourism, promoting awareness and increasing knowledge in the field of technology and digital applications to preserve cultural heritage. Digital innovation and virtualization technologies enhance cultural heritage to analyze a new approach for the impact of material science and documentation in architectural heritage. Finally, there is a great relationship between cultural heritage and virtual systems. In addition, the application of technological methods contributes in preservation of heritage effectively and a safe manner. Consequently, the research discussed the connection between nanotechnology, nanomaterials, 3D laser scanning technology, photogrammetry, virtual reality and preservation heritage. Modern technologies can greatly help to document cultural heritage and produce 3D virtual models. accordingly, the use of these techniques and technological tools will led to green hritage (Figure 58).



The research councluded many results as:

1. Providing a **great opportunity to stimulate tourism, promoting awareness and increasing knowledge in the field of technology and digital applications** to preserve cultural heritage.
2. Digital technologies have had a **tremendous impact on the production, preservation and utilization of cultural heritage.**
3. Use of **biomaterials will enhance Sustainable and more environmentally** preserving heritage leading to **green heritage.**
4. There is a **great relationship between cultural heritage and documentation, virtual reality, material science and technological tools** in the preservation of heritage.
5. **Virtual models** provided a **complete information** to preserve the structure and space.
6. The **digital and biological technologies** used in heritage preservation contributed to **create new possibilities** to produce conservation treatments with improved properties of materials and new functions in the spaces.
7. **Nanotechnology, Nano-materials and Nano-particle** has an important impact in the cultural heritage and construction sector, **improving the durability and enhanced performance of building materials, energy efficiency and safety effects.**

8. Documentation of locations in detail provides complete information to preserve architecture through virtual models.
9. Exploring nanotechnologies and nanomaterials have an active role in preserving heritage and restoring cultural heritage.
10. The advanced 3D laser scanning systems and virtual reality allow for accurate documentation of locations in detail and provide complete information to preserve the structure through virtual models.

12. Conclusion

Digital technology has an essential role in the preservation and promotion of contemporary cultural heritage. The research involved many digital techniques, such as nanotechnology, nanomaterials, documentation, photogrammetry, 3D laser scanning technology and virtual reality, which allowed detailed documentation of locations in detail, in addition, they provided complete information to preserve the structure and space through virtual models. In conclusion, many of the digital and biological technologies used in heritage preservation contribute to create new possibilities for the production of conservation treatments with improved properties of materials and new functions in the spaces. Therefore, nanotechnology and nanomaterials have an important impact in the cultural heritage and construction sector, improving the durability and enhanced performance of building materials, energy efficiency and safety effects. The research is recommended to apply these digital techniques with scientific institutions and cultural academies dedicated to heritage, civilization and research in their effective role in solving many of the problems related to preservation of architectural heritage , in addition, finding appropriate documentation for these heritage spaces. It is also necessary to establish standards and approaches for designers, architects when designing , implementing treatments for the protection and documentation of cultural heritage. Finally, research concludes that the spread of digital tools everywhere has a new relationship with the architecture heritage, and preserve it.

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الملخص باللغة العربية

نهج جديد لتطبيق التقنيات الرقمية في الحفاظ على التراث المعماري New Approach for the Application of Digital Technologies in Conservation of Heritage Architecture

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الملخص: التراث هو ذكرى شعب الثقافة والفنون والتاريخ والأدب والعادات والتقاليد والابتكارات البشرية المرتبطة بمفهوم ذاكرتنا ويمثل الإبداع البشري في الهندسة المعمارية ومساهمتهما في إثراء الحضارة التي ترتبط إلى التاريخ الملموس لثقافتنا. تعتبر المعالم الثقافية والتاريخية من العوامل الهامة لتنمية السياحة ، والتي حفزت نمو صناعة التراث. تتمتع المجتمعات والشعوب بالكثير من التراث الثقافي والهندسة المعمارية التاريخية والمساحات الداخلية التراثية ، وهي ذات أهمية كبيرة وتاريخ أصيل. ولذلك ، فإن الحفاظ على الثقافة والتراث للمستقبل هو مسؤولية الجميع عن عمليات التدهور التي تنشأ عن العوامل البيئية والتآكل والدمار وغيرها . إن التراث الثقافي هو عنصر حيوي في المجتمع الحديث وأهم مكون له في العصر الحديث. في الوقت الحاضر ، وتعد دراسة التكنولوجيا الرقمية مجالاً مهماً في دراسة الحفاظ على العمارة التاريخية. بالإضافة إلى ذلك ، فإن دور المعماريين والمصممين في هذه العمليات له أهمية عظيمة. وهكذا ، فإن التطور المستمر للتكنولوجيا الرقمية يخلق مناهج جديدة لعلوم وثائق الحفظ ، مما يؤدي إلى منهجيات جديدة التي يمكن أن تعيد تدهور العمارة ويمكن أن تحافظ على الوظائف الداخلية للمبنى. ويمثل الشاغل الرئيسي في استخدام الحلول التكنولوجية للحفاظ على العمارة والفراغات الداخلية ، بالإضافة إلى دراسة العلاقة بين الترميم والتوثيق ودورها في الحفاظ على تراث العمارة. فمن الضروري التركيز على تقنيات مختلفة لدراسة المباني التاريخية وتحليلها وحمايتها. وبسبب أشكال الحفظ الرقمي ، توجد مقاييس متعددة والتي تشكل التراث الثقافي ، إلى جانب أهميتها وقيمتها الاجتماعية.

يدرس البحث الحفظ والترميم وعلوم المواد والتوثيق وتكنولوجيا الوسائط. ويسلط الضوء على التحديات الأساسية تجاه النهج المستدامة في الحفظ والترميم الرقمي. تشرح الدراسة وتروج أهداف ومبادئ ومعايير الحفظ. وتهدف إلى تقديم مساهمة أكبر في الحفاظ على التراث وتحليل تطبيقات التكنولوجيا الرقمية في تراث المحافظة على الطبيعة لربط علوم المواد وتكنولوجيا النانو ، التي لا تضر ولا تفقد قيمة المباني التراثية على المدى الطويل. تتمثل مشكلة البحث في تدهور وإهمال المباني التراثية وعدم تطبيق الأساليب التكنولوجية التي تسهم في الحفاظ على التراث بفعالية وبطريقة آمنة . لذا ، فإن البحث يدرس استخدام المواد البيولوجية كأداة للمباني التراثية وتطبيقات التكنولوجيا المتقدمة في مجال الحفاظ على المباني التراثية . بالإضافة إلى ذلك ، فإن التقنيات النانوية والمواد النانوية لها دور فعال في الحفاظ على التراث وترميم التراث الثقافي.

تلقي الدراسة الضوء على نهج مبتكر في الهندسة المعمارية والتصميم الداخلي في بناء الثقافة ، بالإضافة إلى تحدي الفجوة بين الحفاظ التاريخي على البيئة التراثية والحفاظ على الموارد الطبيعية. يسعى البحث إلى تعزيز ثقافة التراث من خلال التكنولوجيا الرقمية الحديثة. لذلك ، يتضمن البحث تأثير تكنولوجيا النانو ، والمواد النانوية ، وتكنولوجيا المسح بالليزر ثلاثية الأبعاد ، والمسح التصويري والتكنولوجيا الافتراضية والعديد من التقنيات الأخرى المستخدمة للحفاظ على التراث. وكذلك تحليل الابتكارات الرقمية في الحفاظ على التراث المعماري من خلال تطبيق التقنيات النانوية والمواد النانوية والجسيمات النانوية والواقع الافتراضي في بناء التراث الثقافي لحماية المباني التاريخية وترميم العمارة التراثية. في الختام ، يظهر البحث دور الابتكارات الرقمية في التراث المعماري والاتجاهات التكنولوجية في تقنيات الحفظ الرقمي. وبالتالي ، فإن دراسة أنظمة المسح الضوئي بالليزر الثلاثية الأبعاد المتقدمة ، والواقع الافتراضي ، والذي يسمح بالتوثيق الدقيق للمواقع بالتفصيل ويوفر معلومات كاملة للحفاظ على البنية من خلال النماذج الافتراضية.

وبالتالي ، فإن دراسة أنظمة المسح الضوئي المتقدمة بالليزر الثلاثية الأبعاد ، والواقع الافتراضي ، والذي يسمح بالتوثيق الدقيق للمواقع بالتفصيل ويوفر معلومات كاملة للحفاظ على التراث المعماري من خلال النماذج الافتراضية. وبالتالي ، فإن هذا يؤدي ويعزز المهندسين المعماريين للاستفادة من الخلفية التصورية والمنهجية للتكنولوجيا النانوية ، وتطوير المواد النانوية الجديدة وتحليل التقنيات الأخرى التي ستزيد من تحسين أداء العمارة. وقد استنتج البحث العلاقة الواضحة بين علوم المواد والتراث المعماري ، والوصول إلى التراث الأخضر والتراث المستدام . فمن خلال استخدام تقنيات التوثيق الرقمية

والتي تعطى بيانات دقيقة للتراث المعماري والفراغ الداخلي يستطيع فريق العمل تحديد الوسيلة الامنة المستخدمة سواء من خلال الحفظ أو الترميم أو استخدام علوم المواد والتي تشمل تقنيات النانو تكنولوجي والمواد الحيوية. إن تحديد التراث والحفاظ عليه هو الخطوة الأولى الأساسية للحصول على نظرة عامة على ثراء وتنوع التراث في مدينة أو منطقة. درس البحث الواقع الافتراضي والنماذج الرقمية ودورها في الحفاظ على التراث. بالإضافة إلى ذلك، فيمكن للمسح التصويري الرقمي والمسح بالليزر وغيرها من التقنيات الحديثة أن تساعد بشكل كبير في توثيق التراث الثقافي. وبالتالي، توفر هذه الورقة تطبيق نهج ومعايير الحفاظ على التراث المعماري. وأوصت الدراسة بوضع قوانين صارمة تحكم عملية الحفاظ على التراث واستخدام التقنيات التكنولوجية دون الإضرار بالتراث على المدى البعيد. تعتبر هذه القوانين الأدوات التي، إذا استخدمت بشكل صحيح، تسمح بالحماية الفعالة للمباني التراثية. عند التعامل مع مدينة أو منطقة تاريخية، يجب أن تأخذ في الاعتبار طبيعة ونوعية التخطيط العمراني، والهندسة المعمارية، مع تاريخ المباني بالإضافة إلى وظيفتها.

الكلمات المفتاحية: علوم المواد، تقنية النانو، المواد النانوية، الحفاظ على الفن، الحفظ الرقمي والفيزيائي، الواقع الافتراضي، المعالم التاريخية، المعالم التراثية، الجسيمات النانوية، التوثيق، المحاكاة والواقع الافتراضي، التراث الافتراضي، النماذج الافتراضية ثلاثية الأبعاد، تقنية التصميم الافتراضي ثلاثي الأبعاد، المسح الرقمي، النمذجة ثلاثية الأبعاد، التصور القائم على الحاسوب، تقنية المسح بالليزر ثلاثية الأبعاد، التصوير الرقمي، التراث الأخضر، إعادة الاستخدام المتكيف، التراث المستدام، الترميم.