DIGITAL HOLISTIC DOCUMENTATION OF CULTURAL HERITAGE: CHALLENGES AND RISKS, TOWARDS SHAPING THE FUTURE

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ABSTRACT:

This paper presents the results of the Horizon 2020 ERA Chair in Digital Cultural Heritage: 'Mnemosyne' project, which aims to achieve excellence in research and innovation in the holistic documentation of the past. The project's research agenda includes six broad thematic areas, which encompass data acquisition, processing, semantic data modelling, knowledge management, data long-term preservation, and data use and reuse. The paper focuses on the key results of the project during which several researchers have been training, some of whom propose presenting their experience in three out of the total seventeen heritage-documentation case studies chosen to be studied and digitized. The paper illustrates the significant results of the case studies and how they can fulfil the needs of the multidisciplinary community of experts. Mnemosyne's research team has developed useful research methodologies for the holistic documentation and digitization of tangible cultural heritage objects, monuments, and sites, as well as novel research approaches regarding their embedded intangible aspects and features.

1. INTRODUCTION

The preservation and documentation of cultural heritage have always been of great importance to societies worldwide, as they represent a crucial part of humanity's identity and history. With the advancements in digital technologies, there has been an increasing interest in creating digital documentation of cultural heritage sites and artifacts. However, the process of creating such digital records presents many challenges and risks that must be addressed to ensure their accuracy, authenticity, and longevity. This paper focuses on exploring the challenges and risks of creating digital holistic documentation of cultural heritage, as well as proposing solutions and recommendations to shape the future of digital documentation in this field.

This paper presents the novel results of the Horizon 2020 ERA Chair in Digital Cultural Heritage: 'Mnemosyne' project, as a useful, timely, and relevant example of 'Heritage Documentation Training Experience'. 'Mnemosyne' is a Coordination and Support Action taking place at the Cyprus University of Technology (CUT) and is funded under the programme 'Establishing ERA Chairs'. The project aims to unlock the potential of the CUT and hereby create a level playing field for research and innovation in the ERA. In this respect, the 'Mnemosyne' project (January 2019 – December 2023) appointed a team of outstanding researchers, to manage the necessary structural changes to achieve excellence on a sustainable basis. The project sets up and implements a research agenda on the holistic documentation of the Past, in support of existing and potential user needs. The holistic documentation lifecycle includes the following six broad thematic areas: (1) Data acquisition; (2) Data processing; (3) Semantic data modelling; (4) Knowledge management; (5) Data long-term preservation; (6) Data use and reuse (Figure 1).

The paper focuses on a selection of the key results of the 'Mnemosyne' project during which several researchers have been training and some of whom present their experience in three out of the seventeen heritage documentation case studies chosen to be studied and digitized during the project and based on the exceptional results of the EU Study VIGIE2020/654 (Study on quality in 3D digitization of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines). Mnemosyne's case studies span centuries of human creation, from the Classical to the Modern and Contemporary periods. The paper will focus on the complexity and uniqueness of three of the cases studies by illustrating their outstanding results and how they can fulfill the needs of the multidisciplinary community of experts (Figure 2).

The selection criteria for all the case studies were in line with the criteria set by European Union, UNESCO and Europa-Nostra for monuments under threat, as well as the recommendations of the International Council of Museums (ICOM) for key artifacts based on specific parameters, such as their use and the materials they were made of, if they were tangible or intangible, movable, or immovable, as all these affect the process of digitization and documentation. Mnemosyne's sites and artefacts have different sizes ranging from the scale of millimetres to tens of meters, such as instruments, wooden panel icons, paper documents, liturgical vessels from precious metals, gold and silver coins, castles, to UNESCO-protected monuments, and even an entire village (Fikardou) placed on the Tentative List of the UNESCO World Heritage.

Mnemosyne's research team, to meet the challenges faced regarding the implementation of the case studies, and to reach remarkable results developed useful research methodologies for the holistic documentation and digitization of tangible cultural heritage (CH) objects, monuments, and sites, as well as novel

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research approaches regarding their embedded intangible aspects and features. These research methodologies and methods include the following: 1) Development of an integrated taxonomy of tangible CH assets to support the representation of movable and immovable heritage complex nature and their embedded intangible heritage.; 2) Creation of a user classification system to categorize, based on the users’ needs, the multidisciplinary community of experts and users involved in the documentation and knowledge of immovable and movable objects; 3) Development of Data Acquisition and Digitisation pipelines, where the complexity and quality of the results based on the collected and used data are fundamental parameters in determining the required effort for digitization.

2. MNEMOSYNE: A UNIQUE TRAINING EXPERIENCE IN HOLISTIC DIGITIZATION

The Mnemosyne project provided a unique training experience for the researchers, adopting an interdisciplinary approach which involved experts from various fields, such as archaeology, architecture, engineering, computer science, and information management. This interdisciplinary approach enabled the researchers to acquire new skills and knowledge from different domains, which contributed to their professional development. The project team provided training sessions and workshops on the different thematic areas of the project, which enabled the researchers to gain hands-on experience with the latest methods and tools in the field.

Furthermore, the Mnemosyne project provided opportunities for the researchers to collaborate with other experts in the field, including international researchers and practitioners. This collaboration enabled the researchers to gain a broader perspective on the field and to establish new connections and partnerships. The project has also contributed to the wider dissemination and promotion of cultural heritage to a broader audience, including researchers, educators, and the general public. The methods and tools developed by the project team allow for the visualization, analysis, and dissemination of cultural heritage data in interactive and engaging ways, such as virtual reality environments and digital exhibitions.

The training experience offered by the Mnemosyne project was particularly unique in that it went beyond traditional academic boundaries and encouraged interdisciplinary collaboration. This approach allowed researchers to gain knowledge and skills from different domains and work together to solve complex challenges in heritage documentation. The project team organized training sessions and workshops on the six thematic areas of the project, providing researchers with hands-on experience with the latest methods and tools in the field. The workshops were designed to facilitate interactive learning and problem-solving, encouraging researchers to work collaboratively to find solutions. Moreover, the project provided researchers with opportunities to participate in international conferences and workshops, allowing them to present their work, share their knowledge, and establish new connections with experts from other institutions. This exposure enabled the researchers to gain a broader perspective on the field and to keep up with the latest developments and trends.

The training experience offered by the Mnemosyne project was instrumental in shaping the professional development of the researchers involved. It enabled them to gain a deep understanding of the interdisciplinary nature of heritage documentation and equipped them with the skills and knowledge required to tackle complex challenges in the field. The project’s focus on innovative methods and tools also ensured that the researchers were well-prepared to tackle the latest challenges in heritage documentation and contribute to the advancement of the field.

3. CASE-STUDIES: THE FIKARDOU VILLAGE, THE FRESCOES OF SAINT EUPHEMIANOS, AND THE HERMITAGE OF SAINT NEOPHYTOS

In this paper we focus on three case studies from the Mnemosyne project, namely: the Fikardou Village, the Frescoes of Saint Euphemianos, and the Hermitage (enkleistra) of Saint Neophytos. These case studies have been selected based on their uniqueness and complexity, as well as their value and importance to the multidisciplinary community of experts. These sites and artefacts have been thoroughly documented and digitized by Mnemosyne’s researchers, utilizing their developed research methodologies for the holistic documentation and digitization of tangible CH objects, monuments, and sites, as well as their embedded intangible heritage features. The team developed methods for the capture of 2D and 3D data, including photogrammetry, laser scanning, and structured light scanning. These methods enabled the capture of accurate and detailed digital representations of cultural heritage artifacts and sites. The project team also developed a range of algorithms and software tools for the processing of captured data, including filtering, segmentation, and feature extraction. These methods enabled the efficient processing of large volumes of data and the identification of key features and structures.

Furthermore, various strategies and technologies to facilitate the accurate representation, efficient management, and long-term preservation of cultural heritage data have been implemented. These strategies included the creation of ontologies and knowledge representations, the development of tools such as data repositories and search engines, and the implementation of metadata schemas. Moreover, the team employed digital curation, migration, and emulation techniques to ensure the continued preservation of cultural heritage data for future generations.

In addition, the project team designed and implemented methods and tools to visualize, analyze, and disseminate cultural heritage data. These included interactive applications, virtual reality environments, and digital exhibitions, which enabled wider access and reuse of cultural heritage data by researchers, educators, and the general public. The project team’s efforts have significantly contributed to advancing the study and preservation of cultural heritage, fostering a deeper understanding and appreciation of our shared history and cultural legacy.

As the aim of Mnemosyne is to create a comprehensive workflow for documenting and digitizing tangible cultural heritage objects, monuments, and sites, along with their intangible aspects and features, the researchers faced several challenges, including the development of an integrated taxonomy of tangible cultural heritage assets that can represent their complex nature and their embedded intangible heritage.

The project’s taxonomy distinguishes between tangible and intangible heritage, focusing on the development of the tangible heritage class. This class is subdivided into movable and immovable heritage, and the key challenge is to determine how to develop the terminology for each category. The classification of movable objects includes function, form, subject type, material/technique, location or context, and state and condition.

Monuments can be classified according to feature, significance, and components (Figure 4).

Another significant challenge for the project was the creation of a user classification to categorize users based on their needs. The project identified multidisciplinary groups of users and categorized them based on their information needs, expertise, and motivation. This provides a way to distinguish between different user groups, including those that are usually under-represented or not considered.

The project also faced challenges in developing pipelines for data acquisition and digitization. Quality and complexity are fundamental parameters for determining the necessary effort for a digitization project. The project team worked on establishing criteria for measuring the quality of produced data, metadata, and para data. Factors that determine the complexity of 3D data acquisition projects include stakeholder requirements, project specifications, personnel qualifications, object type and location, environmental conditions, equipment, real object conditions, and pre-processing software (Figure 5**).** The complexity of digitization projects is also determined by software and hardware parameters such as reliability, operability, compatibility, maintainability, security, computational power, bandwidth, memory, time, cost, and sensor integration. The project team evaluated each of these parameters to ensure efficient data acquisition and digitization.

Quality plays a crucial role in the process of digitizing objects and monuments. The various parameters that contribute to quality include the level of detail, the accuracy of shape, spectral, scale, texture, material properties, chemical composition, and structural health monitoring status. These parameters can be grouped into four categories: Geometry, Image, Material, and Structural Health Monitoring, which are illustrated in Quality parameters vary depending on the type of tangible heritage being digitized, as well as the equipment and methodology used at different stages of the 3D digitization process (Figure 6). Additionally, the intended purpose of the resulting digital material determines the required combination and levels of quality parameters, thereby identifying the minimum acceptable quality level. The level of quality of the digitization process depends on the parameters and para data recorded in the complexity.

The ERA Chair team is currently undertaking a project to digitally preserve and promote **the Fikardou village** in the Digital Era **(**Figure 7**).** Fikardou is on the Tentative List of UNESCO World Heritage, and the project aims to protect and manage its unique components. Data collection was a critical part of the process, which involved reviewing the literature, researching public and private archives, and conducting interviews with the local council and inhabitants to gather information about the village's history and the life of the Fikardians.

The digitization process was divided into two phases, with the first phase using a 360° camera, UAV, digital cameras, video interviews, and other visual data, and the second phase involving 3D scanning of the monuments and holistic documentation of the village. Focusing on the second phase, the team, consisting of two architects and one topographer, after receiving the architectural and topographic plans from the Antiquities Department and other State Departments, dating from the 1960s, carefully planned the process of digitization. Based on the available data, and the missing data, the team selected the tools needed to conduct the holistic survey and digitization of the entire village. The tools identified to be used were the following: aerial photogrammetry, terrestrial laser scanning, ground remote sensing, and georeferencing. Upon visiting Fikardou, a set of challenges and limiting factors, were presented relating to the Object Complexity and the Process Complexity. Specifically, concerning the geometric and structural complexity of the village, as the Object was an entire village consisting of several complexes of inter-connected medieval houses/buildings, and not a single building, the team had to strategically select its scanning positions so that it would successfully implement 3D scanning of the monuments and holistic documentation of the village. In addition, interior scanning was conducted in four monuments (Achilleas Demetris House, Katsinioros House, Linos Wine Press, and Church of Apostle Peter and Paul).

After completing the village's digitization, the team is currently working on creating an HBIM model. The researchers plan to create an application and an e-book that presents Fikardou's tangible and intangible heritage in a holistic approach. The e-platform will consist of interactive menus with educational content, a virtual tour of the entire digitized village, and the ability to access holistic digitized monuments. The project also aims to digitize cycling and walking routes, recording them in GPX and KML format for their integration into a geoinformatics platform to support policymakers and practitioners in assessing cultural tourism strategies and services.

Mnemosyne's second selected case study for this paper is **the Frescoes of Saint Euphemianos** or Themonianos that decorated the Church of Saint Euphemianos from the 13th century (Figure 8). The frescoes suffered significant damage due to humidity, and in 1972, the Department of Antiquities of Cyprus conducted maintenance work on them. The Church of Saint Euphemianos is a significant religious site located in the small village of Lysi, in the northern part of Cyprus. The church was built during the 12th century, in the period of the Byzantine Empire, and is considered one of the most important examples of Byzantine architecture on the island. The church is dedicated to Saint Euphemianos, a Christian martyr who was executed during the reign of Emperor Diocletian.

The Church was originally decorated with frescoes during the 13th century, which depicted scenes from the life of Christ, the Virgin Mary, and various saints. The Church of Saint Euphemianos in Lysi was not spared from the events that took place in 1974 during the Turkish invasion of Cyprus. The church and other cultural and religious sites suffered significant damage during the conflict. The church's frescoes were also damaged, with some of them being destroyed completely. However, thanks to the efforts of local and international experts, many of the frescoes were carefully restored and preserved, allowing future generations to enjoy the beauty and historical significance of the church. Today, the Church of Saint Euphemianos stands as a symbol of the enduring spirit of the Cypriot people, who have faced many challenges throughout their long and storied history.

Mnemosyne's researchers employed a non-destructive approach for pigments identification of the Byzantine wall paintings in the church of Saint Euphemianos in Cyprus. Various natural mineral pigments, as well as artificially produced inorganic pigments were identified in the wall paintings by means of pXRF and pRaman Spectroscopy. The local mineral varieties included mainly red and yellow ochre, umber, green earth. The foreign natural inorganic pigments included lapis lazuli,

consisting mainly of lazurite and cinnabar. The artificially produced inorganic pigments included lead white. The pigments seem to have been used pure or in mixtures and were applied in a single or multiple layer. The yellow paints consisted mainly of yellow ochre, while the brown-reds consisted of different hues of red ochre, yellow ochre, and umbers applied pure or in combination with each other.

More specifically, the researchers employed X-ray fluorescence (XRF) spectroscopy and Raman spectroscopy to analyze the pigments used in the frescoes. XRF allowed for rapid identification of the elemental composition of the materials, while Raman spectroscopy provided a molecular fingerprint of the compounds under study. The two techniques were coupled to provide information on the elemental and molecular composition of the pigments used. The identification of pigments for Raman Spectroscopy was done using the UCL (Clark) database, Pigments Checker, and colourlex.com for pigment analyses of paintings. Various natural mineral pigments, as well as artificially produced inorganic pigments, were identified in the wall paintings using XRF and Raman Spectroscopy. The research was conducted using the scientific software Spectragryph and Thermo Scientific NDT.

In addition to the scientific techniques employed, the role of researchers in this case study was crucial for the success of the project. The researchers responsible for this study had a deep understanding of the materials and techniques used in medieval Cypriot art, as well as extensive knowledge of the cultural and historical context of the Church of Saint Euphemianos. This expertise allowed them to interpret the data obtained from the XRF and Raman spectroscopy and provide meaningful insights into the pigments used and the painting techniques employed by the artists. Furthermore, the researchers collaborated closely with conservation specialists to develop appropriate conservation strategies for the frescoes based on the findings of the study. This involved careful consideration of the environmental conditions in the church, as well as the effects of past conservation efforts on the frescoes. By combining their scientific expertise with their knowledge of the cultural and historical significance of the frescoes, the researchers were able to provide a holistic approach to the conservation and preservation of these important cultural heritage frescoes.

Regarding future work, the project aims to create a digital twin of the church in Lysi, including its frescoes, using a combination of terrestrial laser scanning and UAV mapping. The resulting model will allow people to experience the site and its artwork as they were originally intended, even though the church is currently located in an occupied area. The use of terrestrial laser scanning and UAV mapping technology has become increasingly important in documenting and preserving cultural heritage sites. These technologies allow for the creation of highly accurate and detailed 3D models of the site, which can be used for research, conservation, and preservation.

Unfortunately, political conflicts and instability can often make documenting and preserving cultural heritage sites difficult or even impossible. This particular site is located in areas of conflict that do not prioritize their conservation. This is a significant challenge for the preservation and documentation of cultural heritage sites around the world. However, projects like the Mnemosyne Project are important because they highlight the importance of documenting and preserving these sites, even in challenging circumstances. By using advanced technologies to create detailed 3D models of the site and its artwork, we can ensure that future generations will have a record of these important cultural monuments, even if the physical site is inaccessible or destroyed.

The Church of Saint Euphemianos case study demonstrates the value of interdisciplinary research and the importance of collaboration between scientists and cultural heritage experts. In order to ensure the preservation of this valuable cultural heritage site for future generations, researchers and conservation specialists collaborated to complete this project successfully by combining cutting-edge scientific procedures with their skills and knowledge.

Mnemosyne's third selected case study is **the Hermitage (enkleistra) of Saint Neophytos**, located in the Paphos District, Cyprus, is a celebrated Byzantine monument known for its unique frescoes and its creation from a mountain (
Figure ***9*)**. Saint Neophytos was a prolific writer and historical figure who became a monk at Koutsoventis Monastery at the age of 17. He later became an ascetic and built his cell into a complex comprising three caves, which soon became a well-known spiritual destination. The Hermitage was extended and adorned with paintings in the 12th century and is an important part of the island's intangible heritage. The team has carried out certain activities concerning the digital documentation of the Hermitage, including scanning the exterior of the complex and creating 3D models of the interior. The geometric documentation has been made available to specialists to conduct dedicated studies addressing protection, preservation, structural and environmental problems, and planning conservative repair operations. The documentation has also been made accessible for preparing detailed 3D-printed versions and photorealistic 3D tours of the interior and exterior of the Hermitage. The focus was to obtain a 3D model with high accuracy and detail that includes both the exterior and interior georeferenced in a unique coordinate system. The process of data acquisition included field surveying, terrestrial laser scanning, photogrammetric techniques, and computer vision.

The documentation of the Hermitage is part of a larger effort to digitally preserve and document cultural heritage sites around the world. However, the process of digital documentation presents several challenges and risks that must be considered. One of the challenges is the need to balance the desire for high-quality, detailed data with the practical limitations of the technology and available resources. For example, the team was only able to digitize the upper part of the Hermitage using photos, rather than more advanced laser scanning technology.

Another challenge is the need to ensure the accuracy and completeness of the data, especially in cases where the physical site may be subject to change due to natural or human factors. This requires ongoing monitoring and updates to the digital documentation to ensure that it remains an accurate representation of the physical site. There are also risks involved in the digital documentation process, including the potential for damage to the physical site during the data acquisition process. Additionally, the digital data itself may be at risk of loss or corruption, which could have serious consequences for the preservation and accessibility of the cultural heritage site.

Despite these challenges and risks, the digital documentation of cultural heritage sites has the potential to revolutionize the way that we understand and appreciate these important cultural resources. By creating accurate, detailed digital models of these sites, we can provide access to people who may not be able to visit the physical site in person, as well as preserve the site for future generations. Additionally, the process of digitization is a

technique for aiding in the preservation and conservation of historical structures and monuments. However, it is important that we approach this process with caution and care, and that we are mindful of the potential risks and challenges involved. In the case study related to the monument in Paphos, researchers emphasized the importance of digitization in the preservation of cultural heritage sites. They recognized the potential danger that natural disasters, such as earthquakes and floods, can pose to these sites and highlighted the need to take preventive measures to ensure their protection. The researchers involved in the study identified the crack in the enclosure of the Paphos monument as evidence of the potential damage that natural disasters can cause. To mitigate such risks, they stressed the importance of creating digital records of cultural heritage sites, which can be used to assess the level of risk and inform conservation efforts. Digitization enables the creation of accurate 3D models of cultural heritage sites, which can be used to identify potential structural weaknesses and inform restoration efforts. These models can also be used to create virtual tours and exhibits, enabling wider access to cultural heritage sites, and helping to raise awareness about their importance.

The use of digital technology and surveying techniques for the documentation and preservation of cultural heritage sites has revolutionized the way architects and civil engineers approach these structures. Through the creation of accurate and detailed 3D models, specialists can gain a better understanding of the construction, materials used, and any issues that may need to be addressed to preserve the site.

Geometric documentation, such as sections, orthoimages, and 3D models, is an essential tool for the digitalization of cultural heritage sites. These models can be used to identify the structure and materials used in the construction of the site, as well as any pathologic or vulnerability issues that may exist. The models can also be used to plan and execute any restoration or conservation work that may be necessary, ensuring that the site is preserved for future generations to enjoy.

In the case of the Hermitage, the creation of a high-accuracy and detailed 3D model of both the exterior and interior of the site allowed specialists to gain a better understanding of its construction and any issues that may need to be addressed. This model was georeferenced in a unique coordinate system to ensure correct relative horizontal and vertical positions, providing a comprehensive and detailed view of the monument.

The process of data acquisition for the geometric documentation of the Hermitage involved field surveying, terrestrial laser scanning, and photogrammetric techniques. Terrestrial laser scanning is a highly accurate surveying technique that uses a laser to measure the distance between the scanner and the object being scanned. Photogrammetric techniques involve taking photographs of the site from multiple angles and using specialized software to create a 3D model from the images.

The availability of this documentation to other specialists allows for dedicated studies to be conducted on the monument, addressing issues such as protection and preservation, structural and environmental problems, and planning of conservative repair operations. This information can be used to inform decision-making processes for the conservation and restoration of the site.

4. CONCLUSIONS

In conclusion, the Horizon 2020 ERA Chair in Digital Cultural Heritage: ‘Mnemosyne’ project has demonstrated the potential of Humanities and Digital Technologies for advancing the documentation and digitization of cultural heritage. The project’s research team has developed effective research methodologies and methods for documenting and digitizing tangible cultural heritage objects, monuments, and sites, as well as their embedded intangible aspects and features. The project's focus on use and reuse concerns and the creation of a user classification system and an integrated taxonomy of tangible CH assets have contributed significantly to the project's success.

The paper’s emphasis on the benefits of the project’s research training activities highlights the importance of capacity-building initiatives in the field of Digital Cultural Heritage. The project’s vision of establishing a Centre of Excellence in Cyprus and a Masters Course focused on holistic DCH documentation is a significant step towards achieving a meaningful, inclusive, and sustainable impact on a local, regional, and global level. These initiatives have the potential to further advance the field of Digital Cultural Heritage and contribute to its preservation and dissemination for future generations. The outcomes of the Mnemosyne project have significant implications for the future of Digital Cultural Heritage. The project's successful use and re-use of case studies, combined with its effective research methodologies and methods, have demonstrated the potential for enhanced collaboration and knowledge exchange among researchers, practitioners, and stakeholders in this field.

The digital holistic documentation of cultural heritage is a formidable undertaking but necessary for safeguarding and sharing our collective cultural heritage. A methodical and interdisciplinary approach can surmount the challenges inherent in documenting, digitizing, and preserving tangible and intangible cultural heritage. The case studies expounded upon in this paper have emphasized the intricate and distinctive nature of each cultural heritage artifact or site and underscored the requirement for customized methodologies and approaches for their documentation.

5. FIGURES

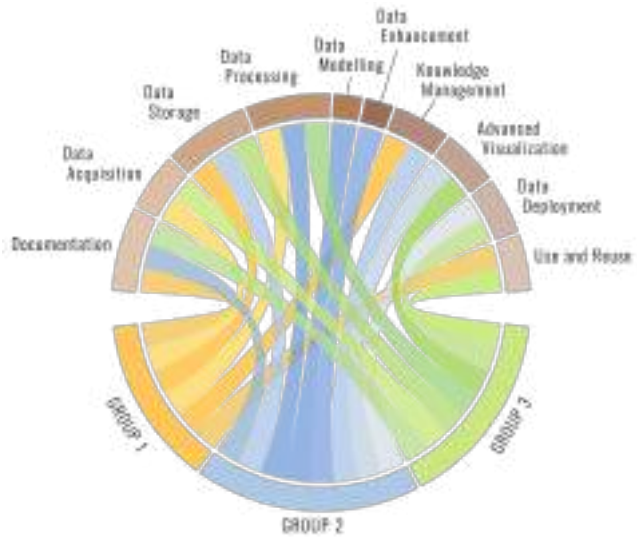

Figure 1: Collaboration among groups in the MNEMOSYNE project

Figure 2: The multidisciplinary community of experts and users involved in the documentation and knowledge of an immovable object, a monument (Church), and a movable object (The Anti-kythera Mechanism).

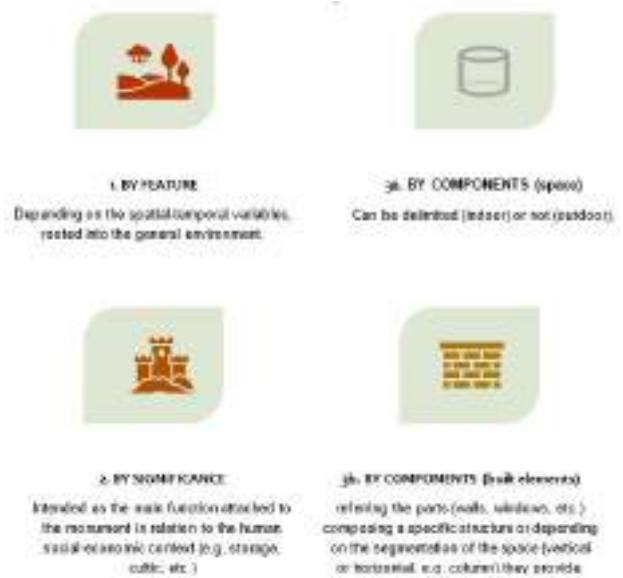

Figure 3: Taxonomy criteria of monuments.

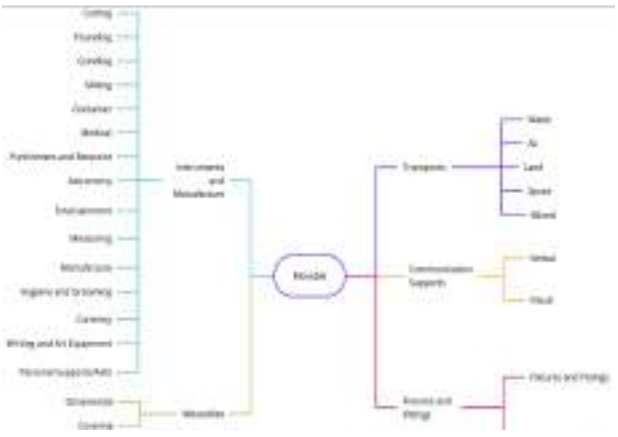

Figure 4: Development of a classification system of movable heritage assets.

Figure 5: Radial chart depicting the parameters for complexity.

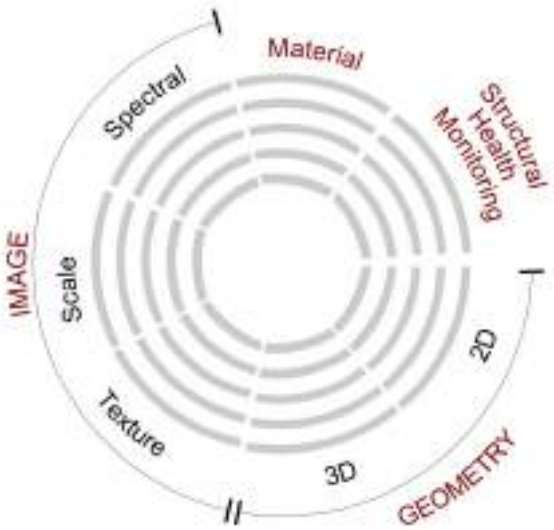

Figure 6: Radial chart depicting the parameters for quality.

Figure 7: Drone Image, Southwestern entrance of the village.

Figure 8: Frescoes of the Saint Euphemianos (Lysi)

Figure 9: The Hermitage (enkleistra) of Saint Neophytos.

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REFERENCES

Aloupi, E., Karydas, A. G., Paradellis, T., 2000. *Pigment Analysis of Wall Paintings and Ceramics from Greece and Cyprus. The Optimum Use of X-Ray Spectrometry on Specific Archaeological Issues*. *29*, 18–24.

Caggiani, M. C., Cosentino, A., Mangone, A., 2016. Pigments Checker version 3.0, a handy set for conservation scientists: A free online Raman spectra database. *Microchemical Journal*, *129*, 123–132. https://doi.org/10.1016/J.MICROC.2016.06.020

Chotzakoglou, C., 2008. RELIGIOUS MONUMENTS IN TURKISH-OCCUPIED CYPRUS, Lefkosia 2008. In *Museum of the Holy Monastery of Kykkos*. Museum on the holy monastery of Kykkos. https://www.academia.edu/3991971/RELIGIOUS_MONUMENTS_IN_TURKISH_OCCUPIED_CYPRUS_Lefkosia_2008

Clark, R. J. H., Franks, M. L., 1975. The resonance Raman spectrum of ultramarine blue. *Chemical Physics Letters*, *34*(1), 69–72. https://doi.org/10.1016/0009-2614(75)80202-8

Department of Antiquities – The Looting of Cultural heritage in Occupied Cyprus. (n.d.). Retrieved October 26, 2021, http://www.mcw.gov.cy/mcw/DA/DA.nsf/All/5C63072411078AB9C22572750055D67D?OpenDocument

Fincham, D., 2015. The Rescue, Stewardship, and Return of the Lysi Frescoes by the Menil Foundation. *International Journal of Cultural Property*, *22*(2–3), 301–314. https://doi.org/10.1017/S0940739115000120

Ganetsos, T., Christ, E., Christopoulou, E., Laskaris, N., Ganetsos, T., 2020. Pigment identification of two post-byzantine icons of Theodoros Poulakis by PXRF and Raman Spectroscopy: Case study. *CHRISTOPOULOU et al SCIENTIFIC CULTURE*, *6*(2), 65–72. https://doi.org/10.5281/zenodo.3785044

Gulmini, M., Ricciardi, P., Idone, A., Christopoulou, E., Ganetsos, T., Laskaris, N., 2021. *Non-Destructive XRF and Raman Spectroscopy Analysis in Pigment Identification of a Wall Painting of the Painter Non-Destructive XRF and Raman Spectroscopy Analysis in Pigment Identification of a Wall Painting of the Painter Nikiforos Lytras from the Chapel of Agios Georgios, Haidari, Athens*. https://doi.org/10.5923/j.archaeology.20210901.02

H2020 ERA chair. (n.d.). Retrieved August 10, 2022, from http://erachair-dch.com/about/

Hegoumenidou, F., Floridou, A., 1987. *Phikardou: A traditional village in Cyprus* (Dr Stuart Swiny, Ed.). Chr. Nicolaou and Sons Ltd, A.G. Leventis Foundation, Dept. of Antiquities.

Jeffrey, George F.S.A., 1918. *A description of the Historic Monuments of Cyprus. Studies in the Archaeology and Architecture of the Island* (William James Archer, Ed.). Governing Printing Office, Nicosia, Cyprus. http://www.archive.org/details/cu31924028551319

Kakoulli, I., Fischer, C. (n.d.). *An Innovative Noninvasive and Nondestructive Multidisciplinary Approach for the Technical Study of the Byzantine Wall Paintings in the Enkleistra of St. Neophytos in Paphos, Cyprus — Dumbarton Oaks*. Retrieved August 10, 2022, from https://www.doaks.org/research/byzantine/project-grants/kakoulli-and-fischer-2008-2009

Katsaros, T., Ganetsos, T., Ganetsos, T., 2012. Raman Characterization of Gemstones from the Collection of the Byzantine & Christian Museum. *Archaeology*, *2012*(2), 7–14. https://doi.org/10.5923/j.archaeology.20120102.01

Kline, Th. R., 2014. Protecting the Cultural Property of Cyprus, Now and in the Future: Opportunities for Broader Collaboration. In *Protecting the Cultural Heritage of Cyprus:*

Joining Efforts in Preventing the Illicit Trafficking of Cultural Heritage (pp. 17–29). Lefkosia: Department of Antiquities.

Menil collection is to return Frescoes to Cyprus. 2011. The New York
Times. https://www.nytimes.com/2011/09/24/arts/design/menil-collection-is-to-return-frescoes-to-cyprus.html?_r=1&ref=design

Papageorghiou, Athanasios, 2010. *Christian art in the Turkish-occupied part of Cyprus*. The Holy Archbishopric of Cyprus.

Philokyprou, M., Limbouri-Kozakou, E., 2015. An overview of the restoration of monuments and listed buildings in Cyprus from antiquity until the twenty-first century. *Studies in Conservation*, *60*(4), 267–277. https://doi.org/10.1179/2047058414Y.0000000136

Returning from Texas at Age 700. 2011. Wall Street Journal. https://www.wsj.com/articles/SB10001424053111903703604576587072924927678

Study on quality in 3D digitization of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines [VIGIE 2020/654], Final Study Report, Cyprus University of Technology, European Union, 2022. doi:10.2759/471776.